undersea technology

including **underwater engineering**

MAY/JUNE 1961
VOL. 2, NO. 3

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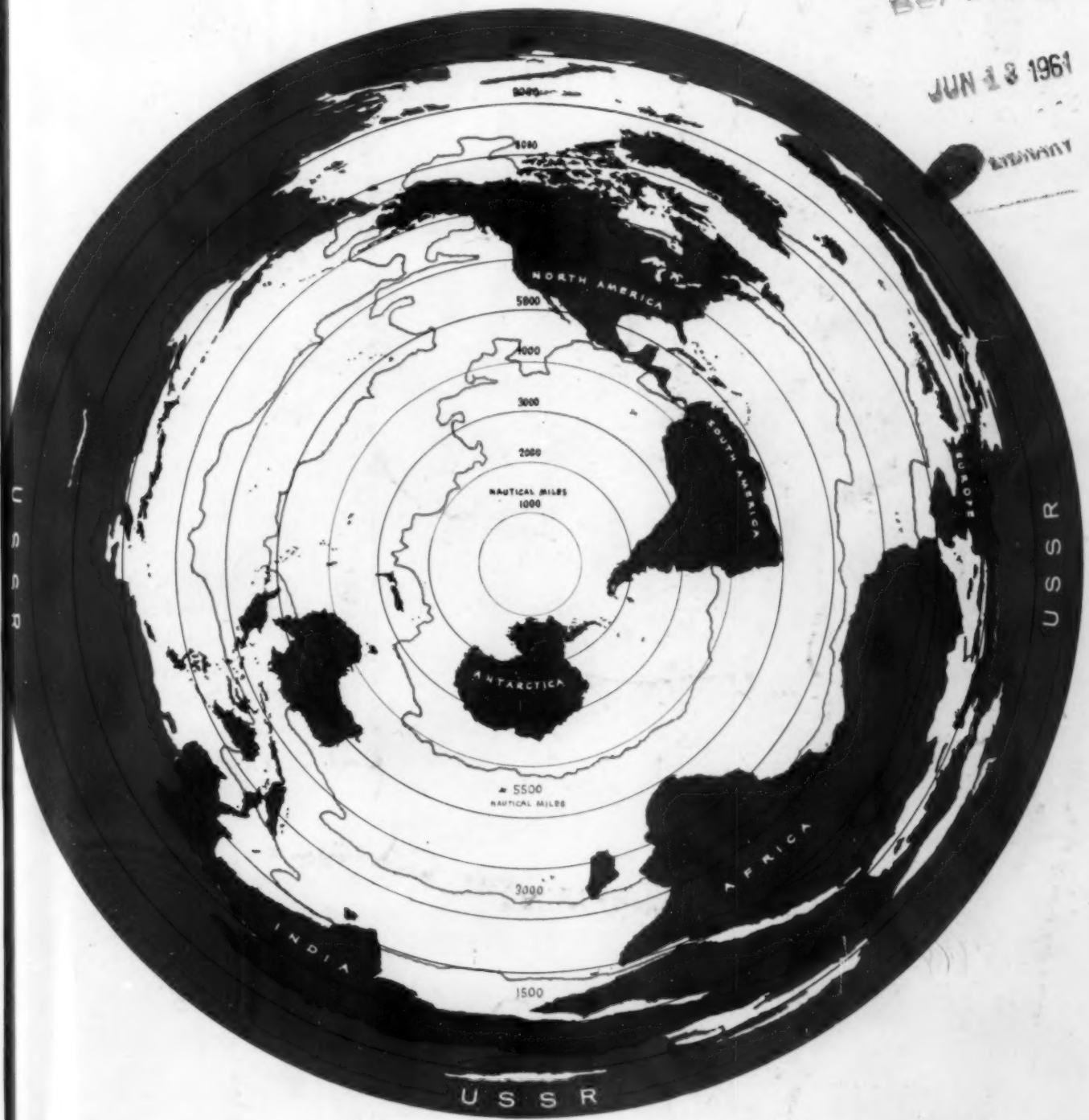

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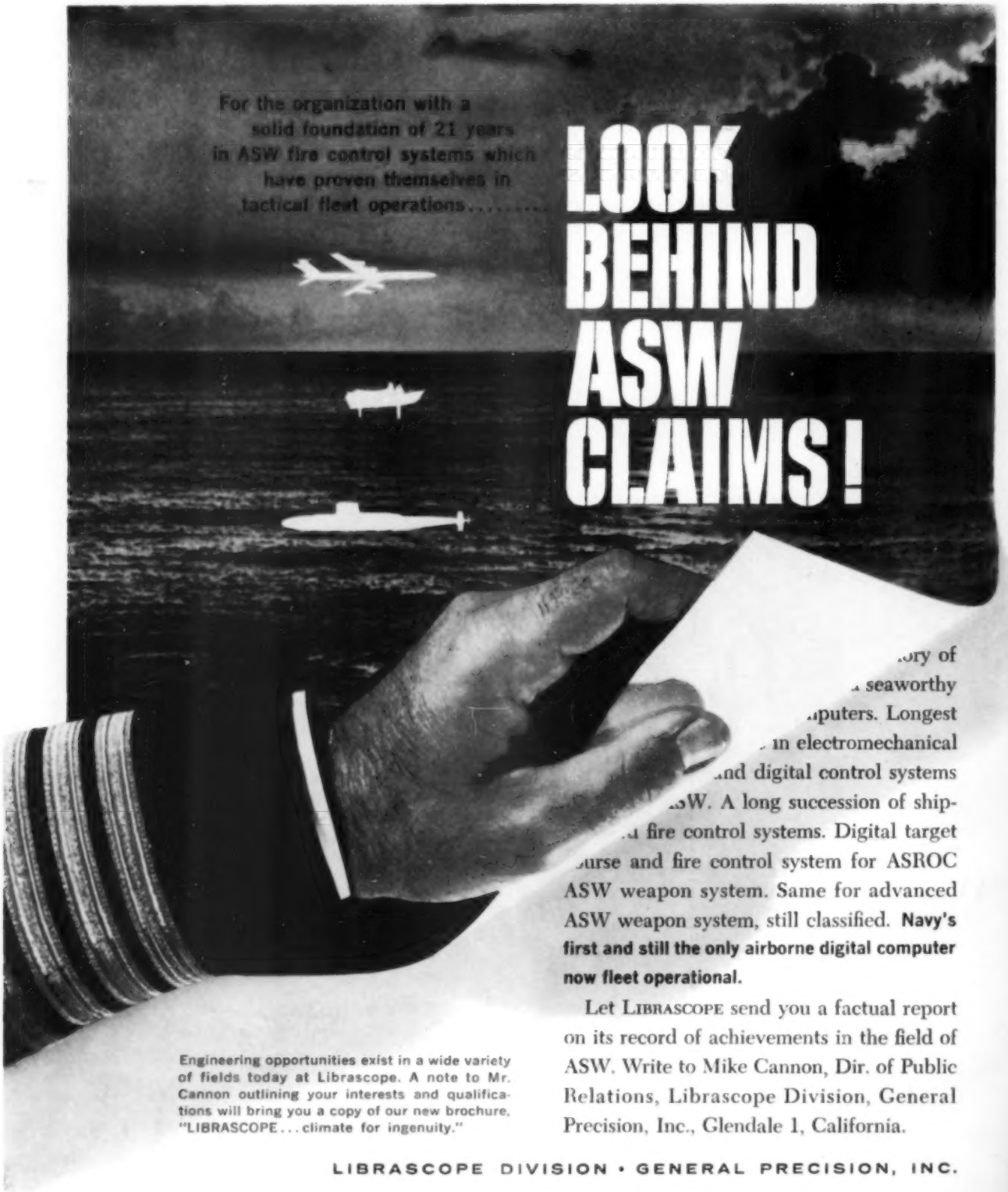
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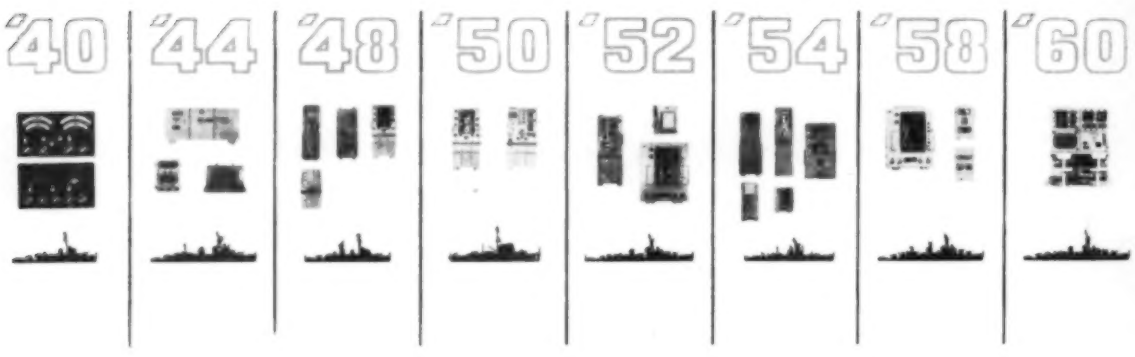

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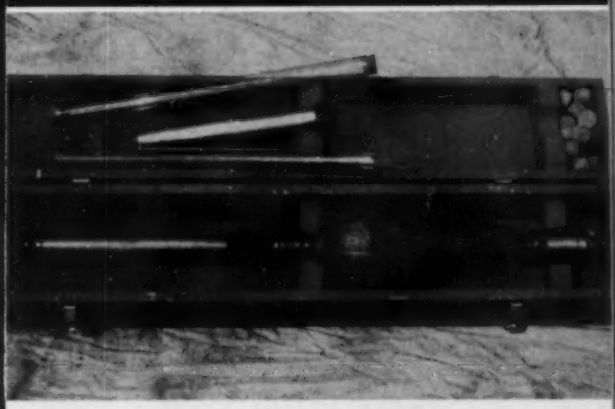

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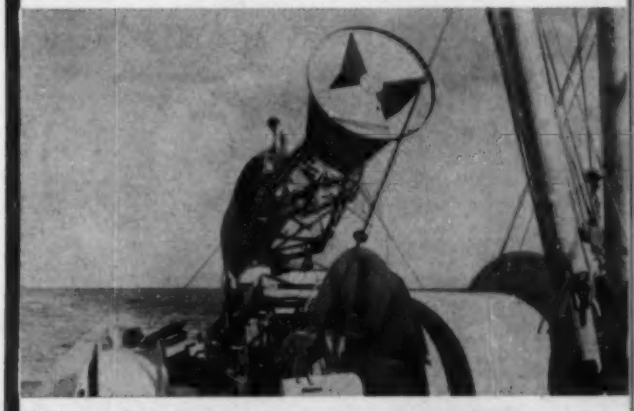

This 12,000 lb. mooring buoy was recently anchored in 5,000 feet of water by MARINE for the U.S. Navy.

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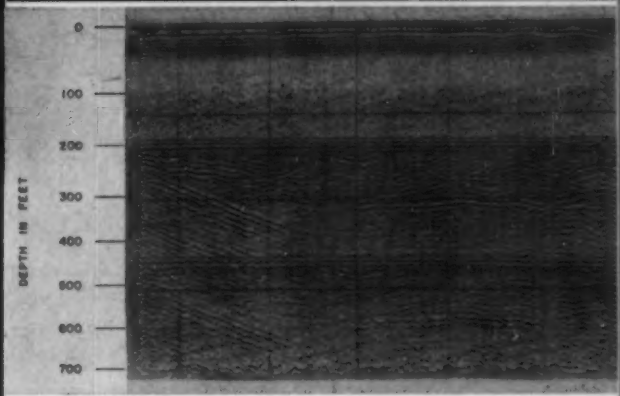

Read similarly to an echo sounder trace, this Sparker reflection record, made by ALPINE during foundation investigations for the English Channel Tunnel, shows the sub bottom strata interrupted by a fault.

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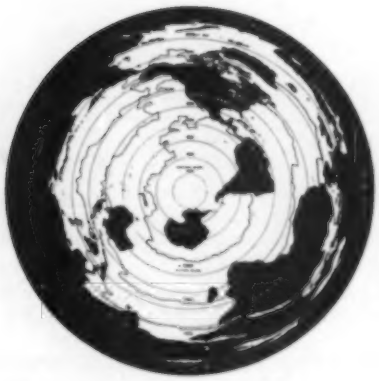
undersea technology



COVER: Like a red mold creeping over the earth, the unique projection on ust's cover shows the USSR empire surrounding the free world. Red grid lines show the ballistic missile (great circle) ranges from the border of Communism. It also shows the strategic significance of the oceans and the importance of the POLARIS Fleet Ballistic Missile system to our security. This map was originally made by Navy's Hydrographic Office and printed in very limited quantities. Credit for working it into a cover goes to our art director, Joseph E. Morse.

Vol. 2 Number 3
MAY/JUNE 1961

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pp. 24&25, LIFE-Fritz Goro; pp. 26&27, LIFE-Ted Lau (Upper Left & Upper Right). National Science Foundation; pp. 29&30, Raytheon Company; p. 36, Pennsylvania State University; p. 48, U.S. Navy & Defense Atomic Support Agency.

Wire

A LINK WITH THE PAST

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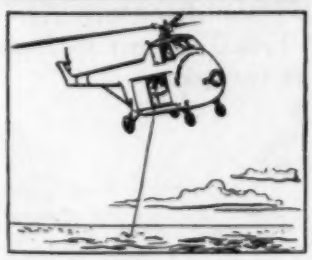

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editorial ★★★★★★★★★★★★★★★★★★★★★★★★★

underwater engineering goes under. . . .

Some former employes have been spreading this rumor, and it looks like they're right. For on this, our first anniversary, we are changing our name to UNDERSEA TECHNOLOGY of which, after all, underwater engineering is but a part. We are doing this in recognition of the growing size of the *ust* market (see special report p. 21, this issue), the realm's mounting military importance, its expanding technological demands, and its emerging commercial potential.

Other changes are taking place as well. In a way we're beginning to feel like a good engineer friend of ours who recently remarked: "Sure, I'm an expert. I've stumbled enough and gotten enough bloody noses." Well, we've stumbled a bit, too—even got a bloody nose or two. But as a result we're beginning to get a pretty good idea of where, and where not to put our feet. This all adds up to one thing: A better, more useful magazine in the future.

Oceanography is the science of the environment and a distinct discipline in its own right. Underwater engineering is the application of other scientific and engineering disciplines to the exploration and useful exploitation of that environment. Undersea technology is the whole ball of wax.

It is the acquisition of fundamental knowledge; the concommitant growth of needs, objectives and capabilities; the interdisciplinary cross-fertilization of ideas and resources; the design, engineering, and fabrication of structures, vehicle instruments, systems; and finally the manning, deployment, and utilization of the products of this technology.

ust will be first and foremost an applications magazine, but like the hen and the egg and A before B, neither needs, systems, nor specific items of hardware can be well-conceived and executed without prior knowledge in depth of the maximum number of factors.

Thus, we are increasing our coverage of oceanography. To companies and people participating in the *ust* field, this is like the three R's, *ust* is not an extension of any other known field of endeavor. The oceans are a unique combination of environmental factors. Individually and collectively these factors determine what you can and cannot do, how, for how much, and for how long.

We are putting new emphasis on articles dealing with structures, materials, and fabrication techniques that produce the best results. We will continue to report on the *ust* market as it actually exists—for research and development efforts, for systems, subcontractor and vendor items. We will probe deeper into the intricacies of ASW within the limits of national security. The POLARIS system is not only one of the most important *ust* markets but has developed many superior techniques: Both will be followed closely.

In the future you will see more on *ust* commercial prospects—with first emphasis on minerals, underwater freight transport, underwater storage, and underwater farming. Skin, scuba, and hard hat diving are important to *ust*. New developments will be covered.

Special emphasis will be given to ust electronics and to *ust* support systems. The editors of *ust* are constantly on the alert for developments in other fields which might aid in solving some of underwater's stickier problems.

You may even see an article or two over the next year on oceanic law. After all, who owns the bottom of the sea? Who will collect amusement taxes from week-end guests in some future "grottoes of the deep" resort? Who will arbitrate claim-jumping disputes in the case of mid-Pacific mineral deposits? Who will regulate (pay for and maintain, for that matter) underwater commercial navigation aids for tomorrow's high-speed freighters?

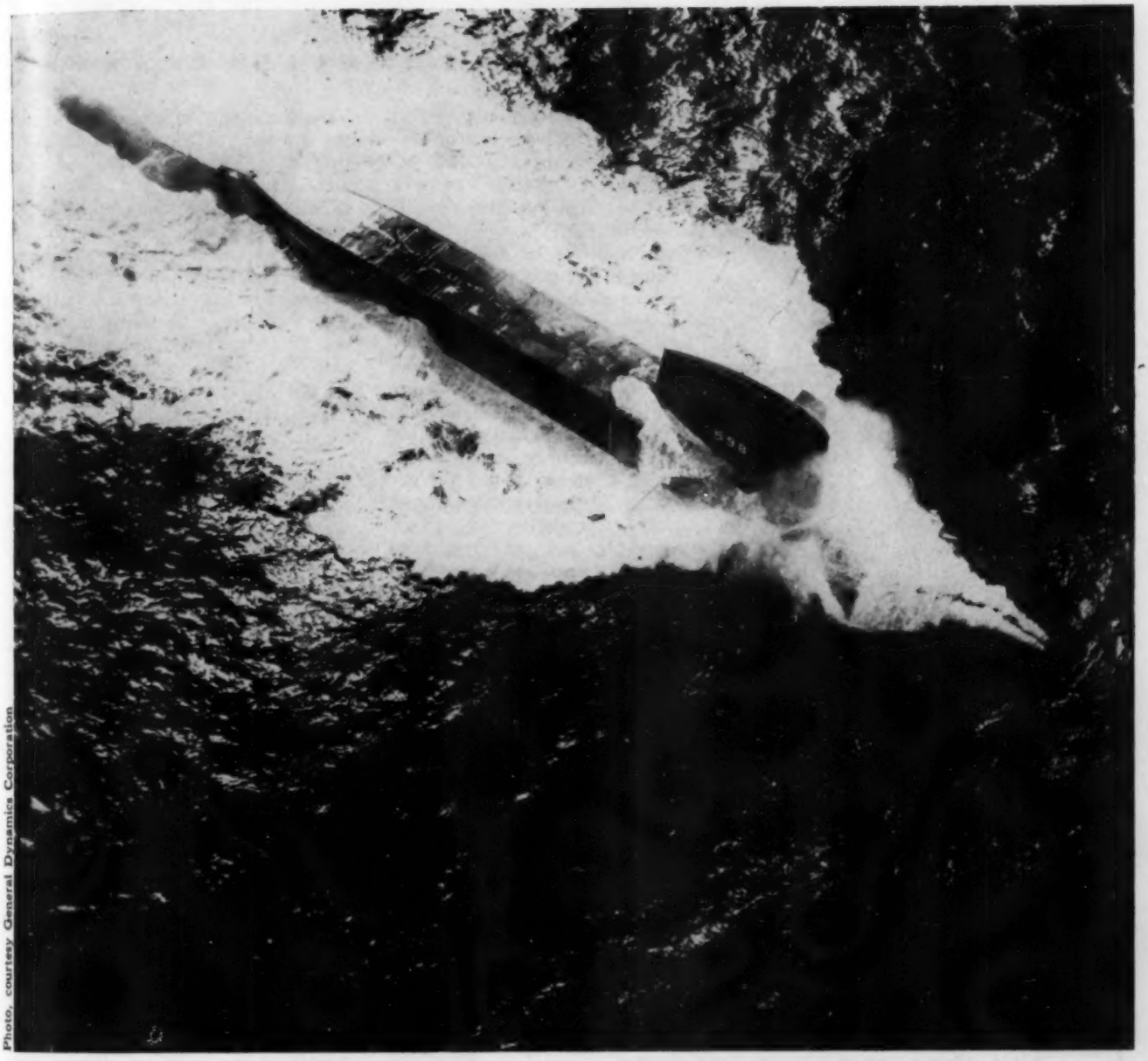
In a word, UNDERSEA TECHNOLOGY is going to be a magazine of undersea technology, dedicated to serving the industry in the most effective possible manner. If we have missed anything or fail to give you what you want in the future, let us know about it. After all, it's your book.

* * * *

Now, a news item we really didn't think worth running, but in view of the guarded inquiries we continue to receive: "We are pleased to announce the departure (lo these many months) of Erik Bergaust to Remson-Whitney Publishing Company. . ."

Seabrook Hull

Photo, courtesy General Dynamics Corporation



Photo, courtesy General Dynamics Corporation

MIGHT on the MAIN

EDO CONGRATULATES THE U.S. NAVY on its mighty deterrent fleet, symbolized by the *U.S.S. George Washington* on operational patrol – fast, far-ranging, Polaris-armed. Edo is proud to share as prime contractor in the Navy's Polaris program by designing and building systems that are being tested and proved daily as the *George Washington* and her FBM sister ships prowl their protective missions . . . "a fleet that will never attack first, but possess sufficient powers of retaliation, concealed beneath the sea, to discourage any aggressor from launching an attack upon our security."*

President John F. Kennedy's State of the Union message, January 30, 1961

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LETTERS TO THE EDITOR ★★★★★★★★★★★★★★★★

Naval Shipyards vs. Private Industry

To The Editor:

Mr. Vaux Owen's letter appearing in your March/April issue recalls to mind correspondence I had with the National Association of Supervisors last year regarding my bill to change the distribution of contracts for repairs, alterations and conversions of naval vessels between Navy yards and private yards.

At that time, Mr. George T. Heilman, National Secretary, wrote me asserting that "naval shipyards can and do perform this work at least 15 per cent below the cost of private industry." I invited Mr. Heilman to submit a comprehensive and unassailable documentation of this statement, and pointed out that in so doing his organization would be performing a commendable public service. But, I heard nothing further until the letter in your magazine came to my attention.

Mr. Owen's latest assertion indicates that his organization has again been less than casual with the facts. Regarding the award of an aircraft carrier contract to a private yard, if he will refer to Department of Defense Press Release No. 1390-60, dated November 25, 1960, he will find that the third paragraph reads as follows:

"A cost analysis of construction costs in naval and private shipyards was a paramount factor in the decision to award construction of this ship to a private shipyard. The successful proposal received from the Newport News Company for construction of the aircraft carrier was more than 40 million dollars below the Navy's estimate for construction in a naval shipyard based on returned costs for carriers completed and nearing completion."

I suggest to Mr. Owen that 40 million dollars is indeed a considerable saving for the government in these critical days, and if private yards can build naval vessels more cheaply, it is logical to conclude that they can repair, alter and convert them more cheaply.

John Marshall Butler
United States Senator

To The Editor:

"Shipways" column in your January issue puts in clear perspective the question of Navy yard competition with private yards involving alterations, repairs, and conversions to naval vessels. More than 75 per cent of this work is presently assigned to tax-free, high-cost Navy yards, and less than 25 per cent is awarded to tax-paying low-cost private yards on a competitive bid basis. This situation evaporates needed tax revenues and excessively draws on the Federal Treasury.

Obviously, Mr. Owen prepared his remarks without first consulting the public record. I have before me a Department of Defense Press Release, dated November 25, 1960, which reads in part: "The successful proposal received from the Newport News Company for construction of the aircraft carrier was more than 40 million dollars below the Navy's estimate for construction in a naval shipyard based on returned costs for carriers completed and nearing completion." $40 million — or the $30 million figure erroneously mentioned by your correspondent — is not a trifling amount, and I am surprised that a spokesman for a responsible national organization should be so disdainful of the true facts, the national interest, and the public treasury.

Mr. Owen also ignores the fact that the 10 naval shipyards and one naval repair facility have capital assets of more than $1.5 billion — I repeat $1.5 billion — in land, buildings and equipment. The total capital assets of the principal shipbuilding and ship repairing companies throughout the country do not remotely approach such proportions. Moreover, the Navy yards are beneficiaries of annual Federal appropriations for maintenance, for improvements, and in many cases for expansion. In the years 1945-1960, the Congress has approved funds totaling $171,853,870 for these purposes. The private yards have no comparable source of munificence, and must rely upon private capital, salesmanship, and efficient and economical operations.

Private shipyards furnished a full measure of productive genius which helped make victory possible in World War I and World War II. Idle capacity in these yards today is causing that productive genius to wither away, while activity in the naval shipyards remains steady. Surely, Mr. Owen would not oppose, in the public interest a change in

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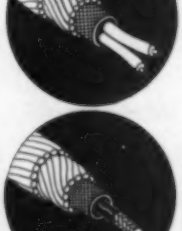

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E. M. Hood
Vice President
Shipbuilders Council of America

We will keep our columns open for further comments in this all important issue. —*Ed.*

Wrong Author!

To The Editor:

An article entitled "Torpedo Water Entry", printed in the March/April issue of *Underwater Engineering*, has been recently called to my attention. The name of Barron Kemp appears in the by-line.

The purpose of this letter is to inform you that the above-defined article was extracted as an abridged version from a more lengthy paper entitled "The Response of Missile Components to Water-Entry Shock", a reproduction of which is enclosed. The original paper was written by myself with the collaboration of C. R. Nisewanger and R. T. Koyamatsu who carried out a major portion of the related experimental work.

You will undoubtedly appreciate the fact that I was somewhat disquieted when I read the article attributed to Barron Kemp. As you can see by a careful comparison with the enclosed paper, the "Torpedo Water Entry" article was extracted sentence-by-sentence and figure-by-figure with little, if any, constructive editing.

The printing of "Torpedo Water Entry" under the by-line of Barron Kemp without credit to or permission from either the original author or the U.S. Naval Ordnance Test Station constitutes ethical, if not legal, plagiarism.

James H. Green
Head, Turbomachinery Branch
U.S. Naval Ordnance Test Station
Pasadena, California

Sorry! The article was presented to us as Mr. Kemp's own work.—*Ed.*

More on Naval Shells.

To The Editor:

Your article in the March/April issue of *UE* on pressure testing facilities by Harold Edgerton of M.I.T. and Lloyd D. Hoadley of W.H.O.I., was an excellent description of the means to set-up a pressure test facility using 16" naval shells.

This Laboratory has gone one step further in the use of the 16" high velocity projectile. In 1955 one of these projectiles was obtained and converted into an acoustic calibration tank to enable us to calibrate hydrophones under pressure. Excellent results have been obtained using this tank for routine high pressure acoustic calibrations of hydrophones required for Hudson Laboratories experimental work.

Details of the System were published in the U.S. Navy Journal of Underwater Acoustics, Volume 10, No. 3, July 1960. The title of this unclassified article is "Accurate Routine Hydrophone Calibration". A limited number or reprints are available.

Harry Sonnemann
Assistant Director
Columbia University
Hudson Laboratories

Thank you for bringing the above to our attention. —*Ed.*

Judicious Reading Prescribed.

Your editorial in the March/April issue of *Underwater Engineering* dissuaded me from reading further. I am not referring to content, for indeed, I could not discern content because of the bombast and fustian. May I prescribe a judicious reading of *The Tattler*, or even better, a dose of John Dryden?

One suspects that you have nothing really worth saying and therefore have fabricated such gibberish as "point of view of pure humanity"; such rant as "the conglomerate assemblage of energy gradients and high velocity particles known as space". If it is known as space, which you acknowledge, is anything gained by adding your sophmoric and high flown definition? Pray tell, what is "pure" humanity?

I trust you have sufficient acumen to edit a magazine and therefore in the future will leave the writing of editorials to those who have some command of our language.

Stephen P. Weintraub
Alexandria, Virginia

We always appreciate constructive criticism. —*Ed.*

Both Involved in SINS.

To The Editor:

As the prime producer of the Ship's Inertial Navigation System (SINS) for the U.S. Navy's POLARIS submarines, we are understandably interested in all published references to this vital system.

Out of such interest, we noted that in your March/April issue's feature story about the POLARIS Mark 80 and ASROC Mark III fire control systems you identified Minneapolis-Honeywell Regulator Co. as manufacturer of a "new compact high-precision inertial gyro for SINS" (photo caption, pg. 24).

Just to keep the record straight, the G-7 gyros in the five George Washington-class POLARIS submarines are Autonetics-produced, as are the entire SINS. So far as we know, Minneapolis-Honeywell is not a supplier of gyros for POLARIS submarines' SINS.

James W. Carey
Public Relations Coordinator
Autonetics
A Division of North American Aviation, Inc.

To The Editor:

Autonetics is nit-picking. Honeywell is *developing* an electrically suspended gyroscope for POLARIS submarine navigation. It is slated for use in connection with the SINS system. At the present time the new gyro is not yet in production and has not yet been assigned to a particular submarine by name.

Your caption would have been completely correct if you had said: "New compact high-precision inertial gyro for SINS, heart of POLARIS submarine's navigation system, under development by Minneapolis-Honeywell Regulator Company".

Forler Massnick, Public Relations
Minneapolis-Honeywell Reg. Co.

Anyone else? —*Ed.*

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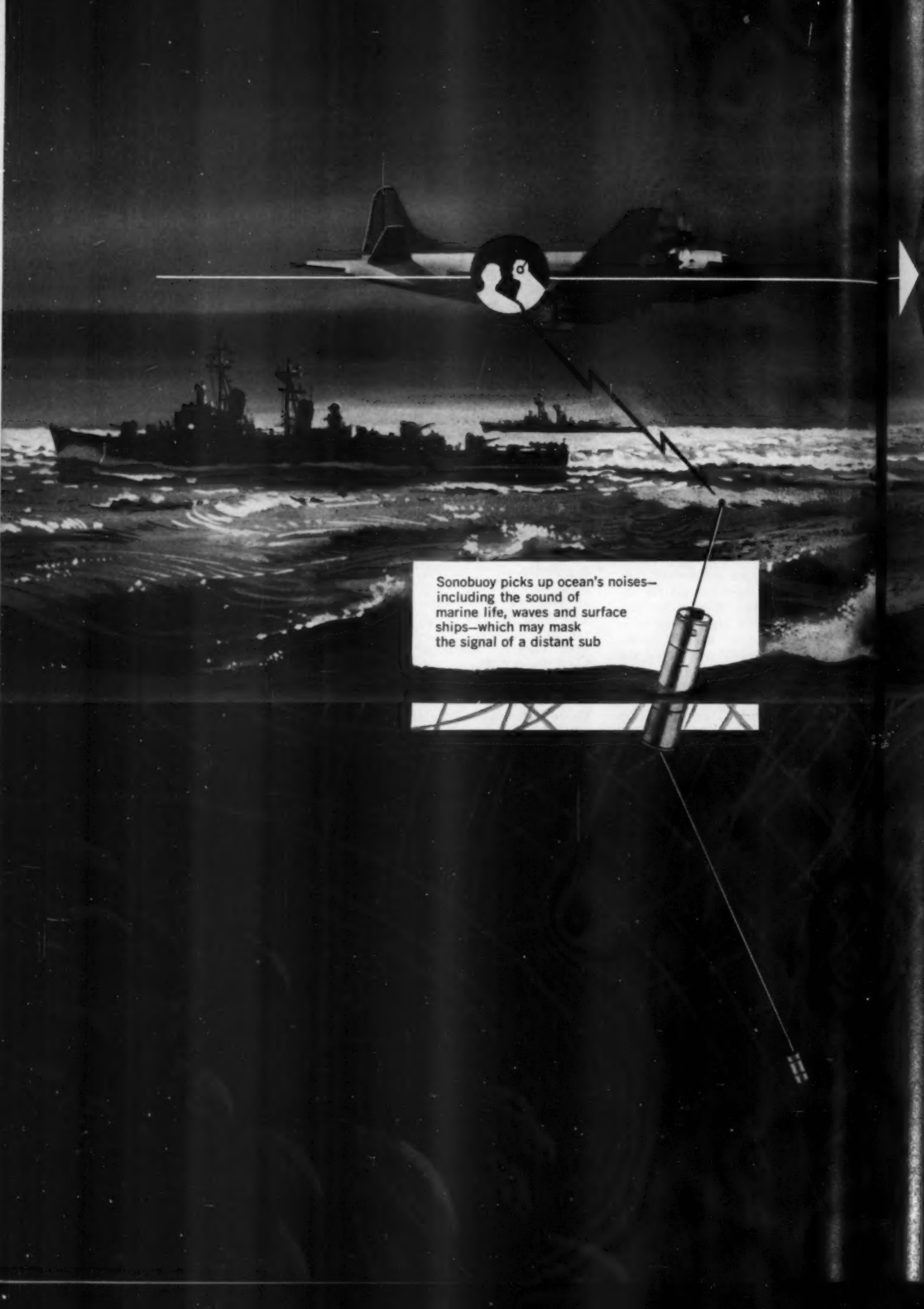
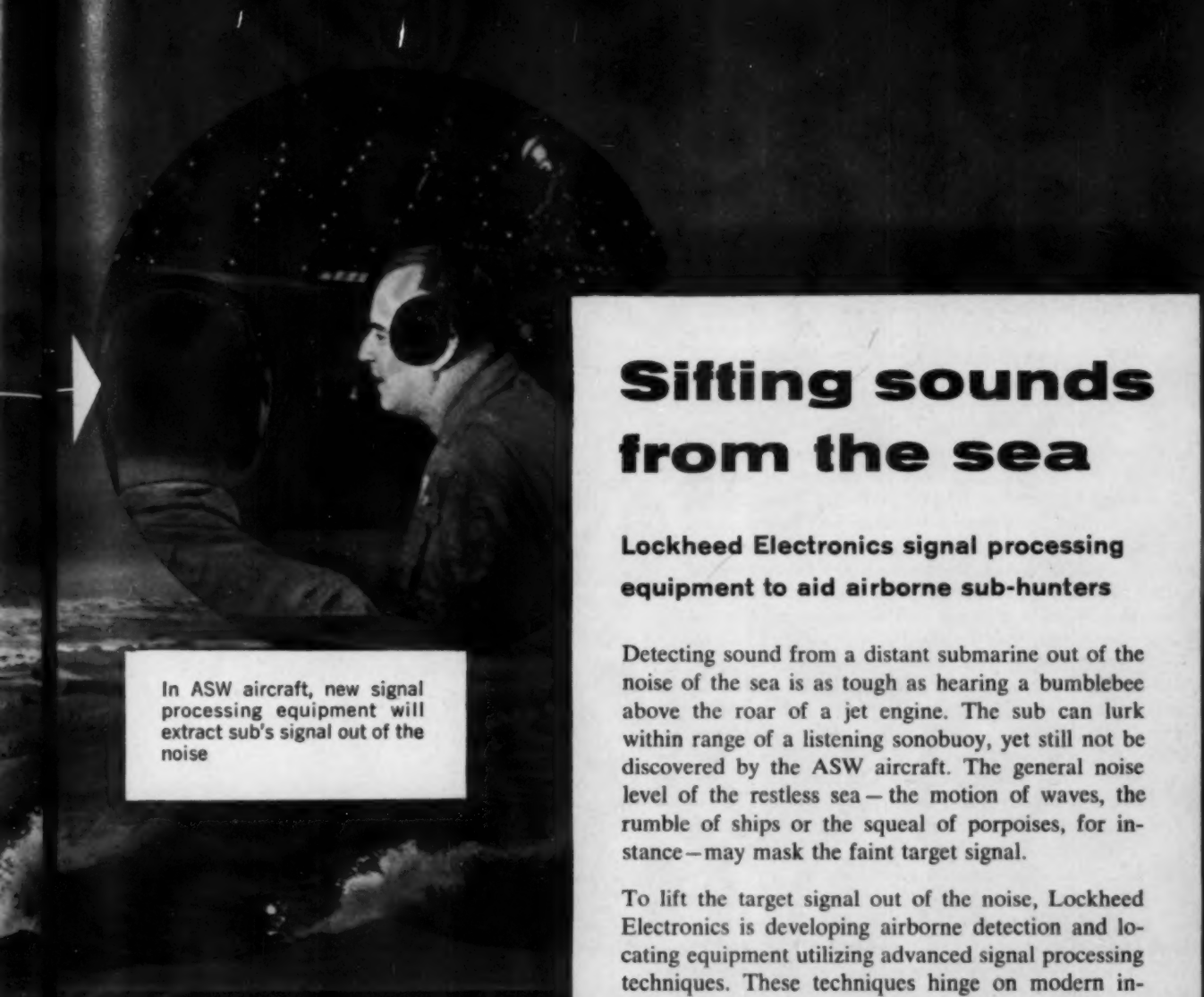


Sonobuoy picks up ocean's noises—
including the sound of
marine life, waves and surface
ships—which may mask
the signal of a distant sub



In ASW aircraft, new signal processing equipment will extract sub's signal out of the noise

Sifting sounds from the sea

Lockheed Electronics signal processing equipment to aid airborne sub-hunters

Detecting sound from a distant submarine out of the noise of the sea is as tough as hearing a bumblebee above the roar of a jet engine. The sub can lurk within range of a listening sonobuoy, yet still not be discovered by the ASW aircraft. The general noise level of the restless sea – the motion of waves, the rumble of ships or the squeal of porpoises, for instance – may mask the faint target signal.

To lift the target signal out of the noise, Lockheed Electronics is developing airborne detection and locating equipment utilizing advanced signal processing techniques. These techniques hinge on modern information theory and noise theory–disciplines employed in optimizing the design of filters, detectors, time integrators and computers to gain improved signal-to-noise ratios.

Lockheed Aircraft, LEC's parent company, has a notable record of achievement in ASW systems. These capabilities are now augmented by the talents of Lockheed Electronics, applied to underseas warfare components and systems.

MINDING THE FUTURE

LOCKHEED ELECTRONICS COMPANY

Plainfield, New Jersey

ust soundings

LATE NEWS

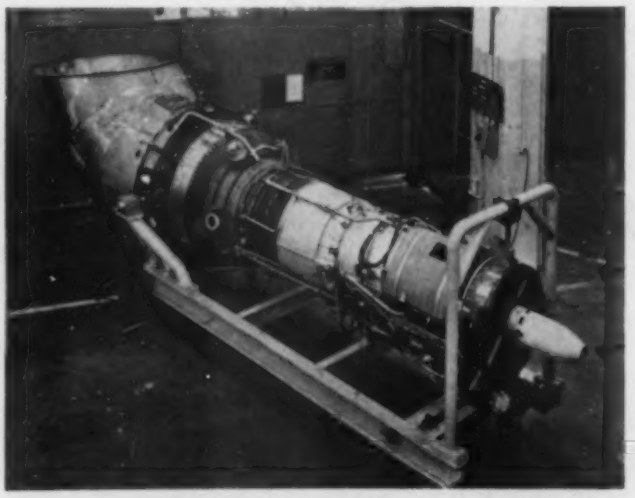
Fish-hunting bats may end up teaching the Navy a thing or two. It seems ONR, in an effort to improve communication and detection system concepts, is investigating the ability of a species of bats *(Noctilio Leoprinus)* to locate fish by emitting ultrasonic pulses . . . A report on the POLARIS missile program will be one of the panel topics at the National IAS-ARS joint meeting being held in Los Angeles June 13-17 . . .

The first National Innerspace Conference is being held May 24-25 in D.C. and will be sponsored by the ASW Advisory Committee of the National Security Industrial Assn. The conference is classified Secret . . . Penna State University is holding several engineering seminars this summer — two of which are **Underwater Acoustics and Underwater Missile Engineering . . . ASROC, the Navy's newest ASW weapon,** has recently become operational in the Pacific Fleet. The new weapon, an important step in ASW, will eliminate closing-in attack by destroyers . . . **A tiny sodium chlorine fuel cell,** not much bigger than a wrist watch, which may eventually become silent power for submarines (see POWER), was described by a Hoffman Electronics Corp. scientist at the Power Sources Conference. The cell delivers twice the power of a normal flashlight cell (same size) and can operate indefinitely since it is continuously recharged. The device can be designed to deliver thousands of kilowatts of power . . .

Aerojet has been named supplier for the **first stage motor in the POLARIS A-3,** which will feature a plastic-glass motor case . . . **Oceanographic instrumentation** will be featured as a subject at the National Telemetering Conference in Chicago, May 21-24 . . . **Two research vessels** recently departed from Annapolis on an oceanographic voyage in the Bahamas to test and evaluate a new type of oceanographic sensor designed and developed by the Chesapeake Instrument Corp. for the Acoustics Branch of ONR. Some of the uses for the sensor will include determining ambient and biological noises, detecting seismic disturbances and detecting ship noise . . . The U.S. Navy's twin-turbine Sikorsky HSS-2 helicopter, scheduled to go into fleet service later this year as a **submarine hunter-killer,** has completed its first carrier suitability trials . . . **Underwater Defense Letter,** Washington, D. C., has prepared a guidebook (for sale) on procurement in the underwater defense field. Included in this sourcebook are various contracting opportunities and a list of 450 major subcontractors on recent underwater defense projects. Specification items for nuclear submarines are also covered . . . **Deep sea diving records were broken** a short time ago when a young Swiss mathematician dived to a simulated depth of 700 feet, performed a physical labor test for 10 minutes, and surfaced in 140 minutes at the U.S. Navy's Experimental Diving Station. Mr. Hannes Keller, interested in physiological problems associated with deep sea diving, credits his feat to a secret mixture of gases and mathematically developed techniques to use them.

MEETINGS

May 26-27	Conference on Peaceful Uses of Space, (NASA); Tulsa, Oklahoma.
June 12	Air Pollution Instrumentation Symposium, (ISA & APCA); New York, N.Y.
June 12-13	Third National Radio Frequency Symposium, (IRE); Washington, D.C.
June 19-21	Heat Transfer and Fluid Mechanics Institute, (Univ. of Southern Calif.); Los Angeles, Cal.
June 22-23	Eighth Annual Symposium on Computers and Data Processing, (Denver Research Institute); Estes Park, Colo.
June 26-28	Fifth National Convention on Military Electronics, (IRE); Washington, D.C.
June 28-30	Joint Automatic Control Conference, (Univ. of Colo.); Boulder, Colo.
June 28-July 1	Annual Meeting, (Institute of Navigation); Williamsburg, Va.
Aug. 7-9	Guidance and Navigation Conference, (ARS); Stanford Univ., Palo Alto, Calif.
Aug. 19-24	Navy Naval Aviation Meeting, (IAS); San Diego, Calif.
Sept. 11-15	Marine Sciences Instrumentation Symposium, (ISA & ALSO); Woods Hole, Mass.



GE's converted J79 turbojet will power the Maritime Administration's experimental hydrofoil — MARAD.

New sub nemesis, "Orion", can deliver depth charges, torpedoes and rockets against underseas agressors.

A Step Ahead of the State of the Art in Anti-Submarine Warfare

400,000-gallon test tube for ASW research

SW research at General Dynamics/Electronics gets a powerful ft from a giant research tool . . . the largest privately-owned indoor cility for underwater acoustic testing. It's a circular, open-topped st tank, 48 feet across, 30 feet deep, complete with automatic st instrumentation for all types of acoustic measurements.

verhead equipment, capable of hefting a 2½-ton transducer, can osition a target or a transducer anywhere in the tank. Measuring quipment can be placed on the surface, to study the air-water terface as part of an acoustic transmission path. Underwater lights nd a viewing port at the fifteen-foot level permit direct observation r photography.

esigned for great flexibility, the tank is the finest ASW research ol in the industry. It provides General Dynamics/Electronics with a commanding capability in the exhaustive testing procedures needed to develop and test advanced Sonar equipment.

Overall, General Dynamics/Electronics has a wide range of experience in the development and production of ASW equipment. Included in this background are the AN/SSQ-38 (XN-2) sonobuoy now under development, the AN/ARR-52 transistorized, high-density sonobuoy receiver now scheduled for production, and the AN/UQS-1D mine-hunting sonar, on which deliveries are now being completed.

For further information about ASW research and development at General Dynamics/Electronics, write: Military Products Division, 1400 North Goodman Street, Rochester 3, New York.

GENERAL DYNAMICS | ELECTRONICS

Circle Reply Card No. 8

MATERIALS

Considered a steel industry "first", U.S. Steel Corp. has announced the commercial production of rolled structural shapes made from quenched and tempered alloy steels. Heat treated to design strengths as much as 3 times that of structural carbon steel, the new shapes are said to promise "important weight and cost savings in a host of structural applications ranging from submarines to skyscrapers." Minimum yield strength is in the neighborhood of 100,000 psi for USS 'T-1' and 'T-1' Type A structural shapes.

A controversial glass-to-metal attachment demonstrated its strength recently when it was used to lift a 6½-ton trailer truck. The edge attachment was designed under sub-contract to Corning Glass Works by Narmco Research and Development. Corning has been working on windshield development for the Air Force for nearly 3 years. The glass (6 x 6 x ⅜ Corning Code 1723 aluminosilicate glass) was mounted in a metal frame with Narmco Meltbond 302 adhesive. Total trailer weight—13,728 pounds—represented a loading of 2,288 pounds per linear inch of bond line.

ELECTRONICS

GERSIS, the General Electric Range Safety Instrumentation System is on its way to installation at the U.S. Naval Missile Facility at Point Arguello, Calif. GERSIS will provide further precision instrumentation capabilities to the range safety equipment already in operation at the Pacific Missile Range.

Amperex has entered the logic module field with the introduction of twelve basic circuit blocks. Featuring high reliability they are designed for machine control, digital equipment, medical electronics, and any other application where logic functions are required.

A 32-track simulator, developed by the General Applied Science Laboratories, is being installed as a major portion of the checkout equipment in the development of the Naval Tactical Data System (NTDS). NTDS centers around a computer which feeds a series of consoles that display a schematic picture showing the enemy targets, their type and movements and the defensive and offensive posture of friendly ships and aircraft.

DOD's most powerful computer, the Univac Lark II, has recently completed acceptance tests at the Applied Mathematics Lab of the David Taylor Model Basin. Problems of concern include design of nuclear reactors for ships (NAUTILUS and SEA WOLF subs), ships and aircraft propeller characteristics, and analysis of collapse pressures of submarine hulls.

SOLARIS, an underwater robot used for recovering torpedoes, passed all tests at the Naval Torpedo Station, in Wash. A protege of Vitro Labs, the robot dived 650 feet, recovered a 5-gallon coffee can and spotted salmon and sand sharks at the bottom of Dabob Bay.

COMMUNICATION, NAVIGATION

The most accurate navigation system, the POLARIS system, will be under the vigilance of the Sperry Dynamic Simulator in an attempt to improve accuracy. The new simulator, capable of mathematically reproducing sea and weather conditions, will seek to improve the navigation system through an examination of its errors.

The Suitcase, a portable "command center" that can be plugged into the bridge of a submarine when surfaced, is being manufactured by the Scintilla Div. of Bendix. The unit is about the size of a portable typewriter and is designed to replace a number of instruments permanently installed on submarine bridges.

Predetection recording techniques for the acquisition of data from the POLARIS missile program are now employed by the Navy. Developed and manufactured by Mincom Div. of 3M, the single-rack system (designated CM-100), provides a 7-track capability and a frequency response from 400 cycles to 1 mc. Data is recorded directly from the IF carrier achieving greater system reliability.

POWER

POLARIS re-vamping — a new liquid injection thrust vectoring system and a telescoping second stage nozzle — will undergo flight tests this summer. Both concepts, considered "firsts" in missile applications, will result in simpler construction and weight reduction in

Panel of the Sperry Simulator controls sea conditions for testing of Polaris navigation system.

Curtis-Wright simulator by Technical Animations, cuts training time by 40 hours with unique training aid.

the 2500-nautical mile A-3 vehicle.

Fuel cell operated submarines, almost completely silent, may augment the Navy's nuclear-powered fleet. Plans for converting a conventional diesel-fueled sub are expected to show themselves next year. Designed as a special-purpose attack craft, the fuel-cell sub will have less cruising range than nuclear type, but nevertheless be able to remain submerged for several weeks.

SURFACE CRAFT

An experimental hydrofoil craft will go into operation this summer powered by a converted aircraft jet engine — GE's model 240 turboshaft power plant. Jet exhaust is converted into shaft horsepower through the addition of a windmill-type power turbine. The 104-foot MARAD hydrofoil, a product of Dynamic Developments, Inc., is expected to reach speeds up to 60 knots.

CONSTRUCTION

Another nuclear-powered submarine — the *Flasher* — designed as an anti-submarine vessel equipped with a labyrinth of underwater listening devices, is under construction at the shipyards of the Electric Boat Div. Two sister ships, the *Greenling* and *Gato*, are also under construction at Electric Boat.

ASW

ORION, the "great hunter of mighty strength", according to Greek mythology, is the appropriate namesake for the Navy's "longest-reaching, hardest-hitting subclubber in aviation history". The new Lockheed P3V-1 aircraft represents a culmination of 15 years of ASW research and development advancements. Featuring the most effective electronic, sonic and magnetic equipment devised for ASW, the ORION will search, detect, localize, identify and destroy any type submarine. Cruising speed is 400 mph plus, but perfect controllability is maintained at 175 mph for sea-level searches.

LIFE SUPPORT

An inflatable gymnasium, containing a punching bag, rowing machine, weights and other equipment, is being installed on the nuclear sub, *USS Theodore Roosevelt*. Adequate recreation, according to Commander W. E. Sims of the *Roosevelt*, is "one of the basic necessities" of a submarine crew. The gymnasium,

Contour Turning—

—tailored to undersea technology

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Aluminum	Nimonics
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an inflatable room made of a rubberized fabric material by Goodyear, will prevent crewmen from injuring themselves on the subs structures.

NEW TECHNOLOGIES

A technique for the production of neutrons in the 8-to-11-million-electron-volt range, previously unobtainable with 16w-energy accelerators, was recently revealed by Lockheed nuclear physicists. The technique involves bombarding a target of radioactive carbon (C^{14}) with heavy hydrogen particles known as deutrons, with a conventional 3-million-volt Van de Graff generator. After impact a proton is stripped from the deutron leaving a neutron which receives nearly 8-million more volts of energy than the incoming deutron. The discovery was made while performing studies for the AEC.

OCEANOGRAPHY

The Meteorology/Oceanography group of Borg-Warner has recently been expanded and is contemplating oceanographic instrumentation studies on wiresonde and dropsonde equipment, manned depth probes and remote probes to depths of 10,000 feet and below. A long-range Weather Research Program for the Federal Aviation Agency is currently under study.

Biological oceanography will be the main concern of a 172-foot two-masted schooner, a gift to Stanford Univ. from philanthropist George Vanderbilt. The Nation Science Foundation awarded the school a $463,000 grant to convert the ship into a modern sea-going marine biological vessel.

TRAINING

Motion without movement is probably the best way to describe TECHNAMATION, a new visible aid technique developed by Technical Aniamtions, Inc. Technamation does with one transparency what normally a minimum of 20 frames would do, and that is . . . produce motion. This is accomplished by using various transparent materials glued into position where motion is desired. Light is then passed through a revolving polarized disc producing the effect of motion on the transparencies. The method has been applied to everything from blood circulation and watch movements to filtering plants and jet engines. Training aids have been made to facilitate teaching the operation of engines showing intake, combustion, compression, propulsion, fuel flow, etc. POLARIS and TITAN are just two of the many missiles that have been subjects for Technamation.

CONTRACTS

POLARIS seems to be suffering from an overdose of contract-itis. A $9.5 million letter was awarded to Interstate Electronics Corp. to design, manufacture and test instrumentation systems for the new SSBN 616 class POLARIS subs. General Electric has received a $20 million contract for advanced fire control systems and a $4.5 million contract for Mark I inertial guidance systems, both for the POLARIS missile. Contracts totalling over $53 million go to GE and Westinghouse for nuclear reactor components. Huyck Systems Corp. gets $3 million for a tactical ASW display and computer system to be used aboard the Navy's ASW plant, the S2F-3 *Tracker* . . . President Kennedy has increased the POLARIS program to the tune of $1.34 billion which will involve acceleration of the long-range POLARIS A-3; increase the number of POLARIS missiles for practice firing; and bring the total number of POLARIS submarines to 29 . . . Cancellation of plans to POLARIS-arm the Cruiser *Long Beach* will result in savings of $58 million for FY 1962.

SPECIAL UNDERWATER CABLES

Watertight Coaxial Cables for Polaris

Now available! Coaxial cables which maintain hydrostatic integrity at pressures 500 and 1,000 PSI. Recent applications met the specialized demands of the Polaris missile firing submarines. The antenna mast system required coaxials* with the ability to withstand 500 PSI on the exposed end without leakage. In addition, they must remain watertight following subjection to an "S" bend at −54°C. BIW bonded polyethylene dielectric to the conductors and compound blocked the shielding braid. Care was taken to avoid altering the cable attenuation at prescribed frequencies. Rugged neoprene jackets were extruded by special techniques which controlled the O.D. and assured a tight fitting cable in the stuffing glands. Flexible armored versions are available.

***RG-293/U and RG-294/U**

Watertight Multiconductor Cables

BIW is making "SW Type" multiconductor cables which will not leak under pressures of 500 and 1,000 PSI on the exposed end of the cable. Used for missile and control cables they are reliable beyond Navy tentative specifications. These are 1 SWA, 2 SWA, 3 SWA, 2 SWU and 3 U. All butyl insulated conductors with no leakage at 1,000 PSI are used for Polaris and other submarine applications. Typical of this type is a modified version of MWF-24.

We will be glad to send information and reports on the performance of all these cables.

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The SILENT VALVE raises the efficiency and lowers the maintenance cost of most fluid systems, whether liquid, gas, or slurry. There is minimum pressure loss in the wide-open position, and quiet flow control over the full range to complete shutoff. Flexible in size and scope, the SILENT VALVE can be supplied for installation in systems with line diameters from one inch to many feet.

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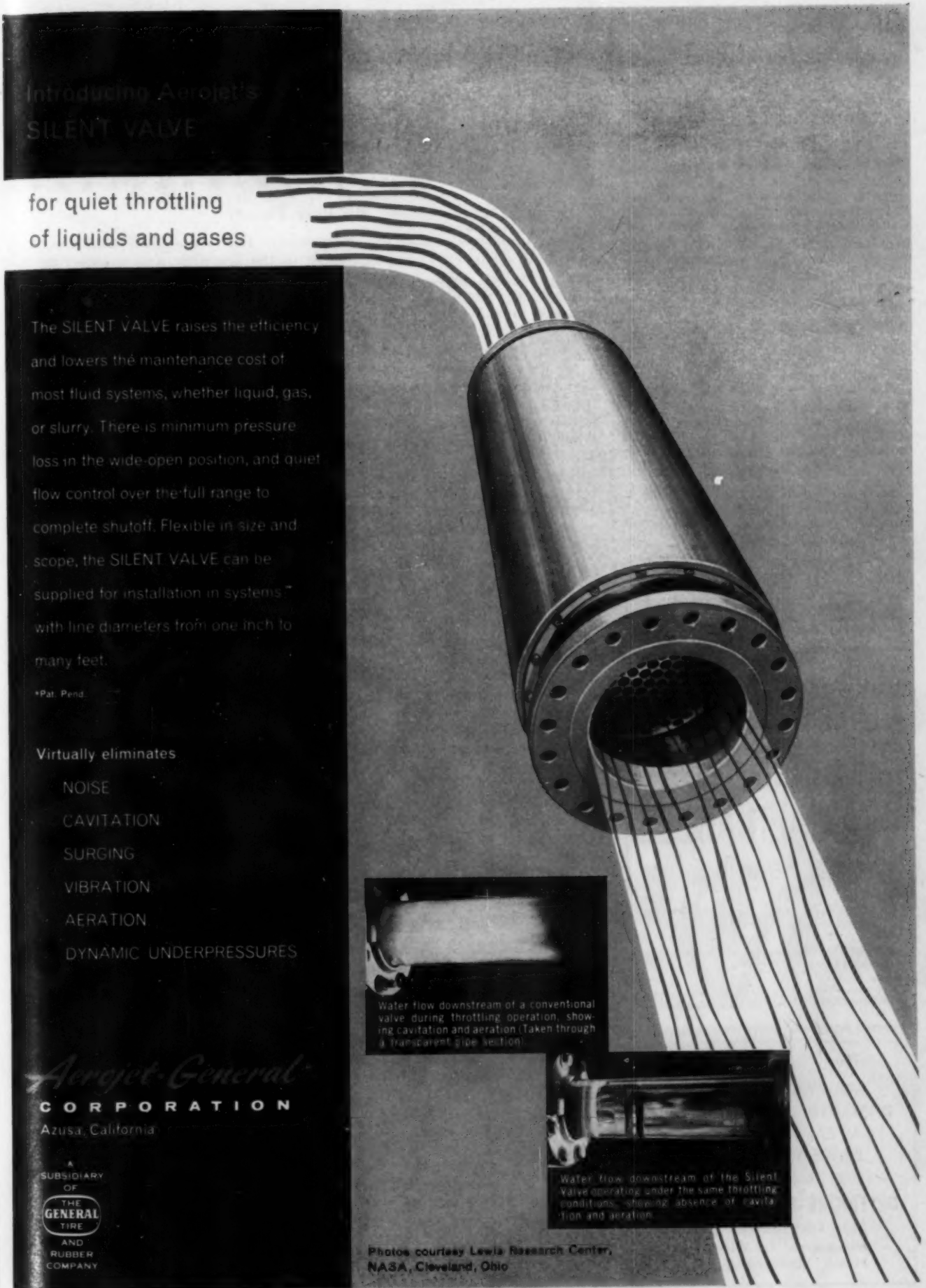

Water flow downstream of a conventional valve during throttling operation, showing cavitation and aeration (Taken through a transparent pipe section)

Water flow downstream of the Silent Valve operating under the same throttling conditions, showing absence of cavitation and aeration

Photos courtesy Lewis Research Center, NASA, Cleveland, Ohio

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Requirements include a strong background of proven experience, plus personal knowledge of instrumentation, techniques and basic literature. Work experience in connection with high-speed crafts, hydrofoils, submersibles and helicopters is highly desirable. Salaries will match your educational and experience background. You'll find the professional environment at Boeing conducive to rapid advancement.

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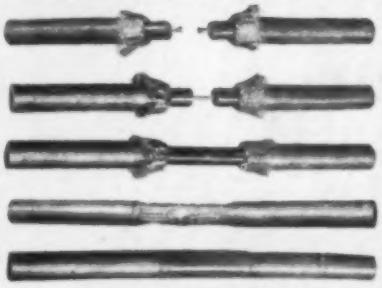

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undercurrents

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By Peer Fossen

More brain-power and less man-power. This was USAF Undersecretary Joseph V. Charyk's recent challenge to the scientific and engineering fraternity to live up to its responsibility in solving the defense problems at hand. "I am deeply disturbed," Mr. Charyk said, "by all too frequent evidence of technical irresponsibility, of attempt to see contract gain through dramatic representation to the military of concepts that are technically unsound or highly speculative but are represented as attainable at an early date and at low cost. Sometimes accomplishment seems to be measured by the size of the contracts required to complete the job rather than by the efficiency with which the job was executed."

We are particularly interested in one sentence in Mr. Charyk's speech, which was delivered at the banquet honoring Dr. Theodore von Karmen on his eightieth birthday. Said Mr. Charyk: "We tend to substitute glossy proposals for sound technical ideas and we oftentimes confuse technical concepts with demonstration models."

This attitude must take the blame for many of our blunders in the past. The most glaring example dates back to the days of the Stewart committee and its decision to favor VANGUARD over ORBITER, thereby permitting the Reds to take the lead in the space race. After the Stewart Committee had picked the VANGUARD (incidentally, Homer J. Stewart, after whom the committee was named, voted for the ORBITER concept) one spokesman for the group stated to this reporter: "Well, ORBITER lost out because of Dr. von Braun's lousy presentation before the committee!" In spite of the "lousy" presentation, credit must go to von Braun and his ideas and concepts. So far his REDSTONE has been the power behind a lot of "firsts" including the first U.S. satellite, and the first U.S. astronaut in space.

* * *

Our sincere congratulations to Vice Admiral William F. "Red" Raborn, Jr., U.S. Navy Director of Special Weapons, who on June 15 will be the recipient of the Robert J. Collier aviation award. The citation accompanying the award reads: "To Vice Admiral William F. Raborn Jr., under whose direction the United States Navy, science, and industry created the operational Fleet Ballistic Missile Weapon System—POLARIS."

Since 1920, the Collier award has been presented by the President of the United States at a ceremony in the White House. This year's presentation marks the golden anniversary of the trophy. Following the ceremony there will be a luncheon to which all live award-recipients of years past have been invited.

* * *

The MOHOLE deep-sea drilling project (see article on page 24 this issue) has a considerably greater interest than the purely scientific one of finding out what is under the Earth's crust. During the recent successful drillings, oil companies, for instance, had technologists on board the drilling ship as observers. Their interest was: a) to see if deep-sea drilling techniques can be applied for oil drilling; and b) to get further data on the origin of oil flow. Other mineral extraction companies are also interested in the possibilities of deep sea mining.

* * *

Even if our NATO allies should turn down the offer for the five POLARIS FBM submarines — with a total capacity of 80 missiles — the POLARIS itself could be deployed overseas.

R & D at present centers around placing the operational weapon aboard surface ships, putting it in permanent land bases, or using it with mobile launch systems involving trucks, flatcars, and barges. The missile would in all cases be air ejected before ignition. Actually, very little work would be required to arm our allies with the POLARIS sans the nuclear subs. Special Projects, as a result of the POLARIS development work is very familiar with surface-ship launchings (S.S. Observation Island) and launches from land (Cape Canaveral ship simulator.)

Another example of Bendix capabilities in electronics:

NEW "SUITCASE CONSOLE" BUILT BY BENDIX PROVIDES PORTABLE CONTROL CENTER FOR SUBMARINE COMMAND

This new console lets the submarine commander easily carry his command center to the bridge when the ship surfaces. All instruments needed for conning information and communications are in an 18-lb. package.

On the bridge, the console has a simple, plug-in connection with a single hull penetration replacing the several required by permanently installed controls. Since the "suitcase" is stowed below when the ship is submerged, the individual units cannot fail through flooding or pressure. And, because the units don't need pressure-proofing, each is smaller, lighter and less expensive than conventional equipment.

Portsmouth Naval Shipyard developed and tested the system, and Scintilla Division of Bendix has manufactured and delivered several ship systems. Bendix has produced many types of cables and connectors for underwater applications, airborne and ground-based installations. If you have needs in these areas—write today for complete information.

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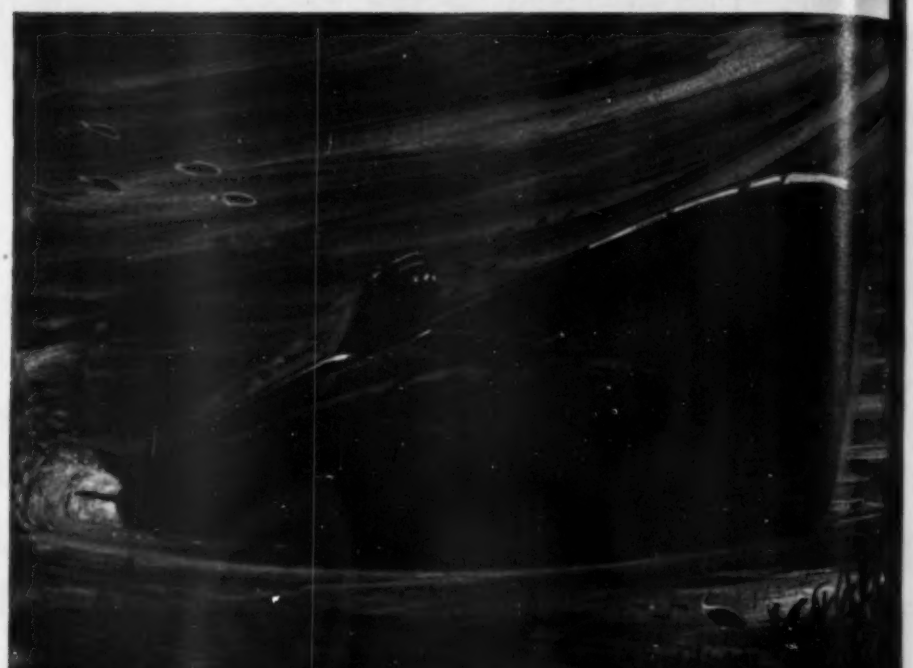
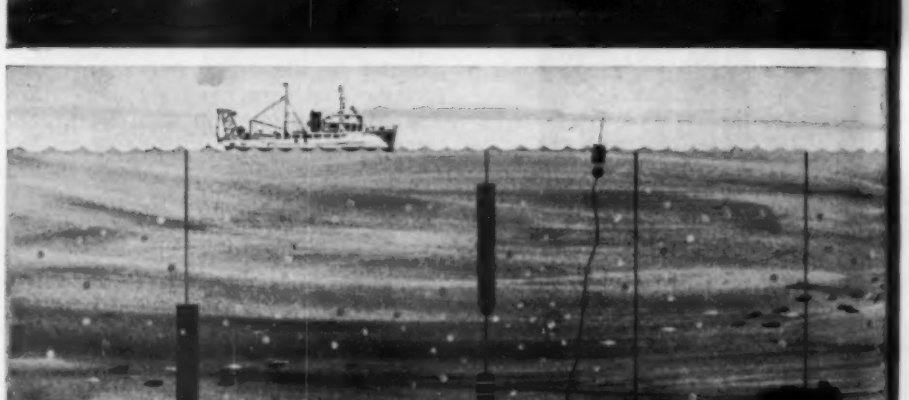
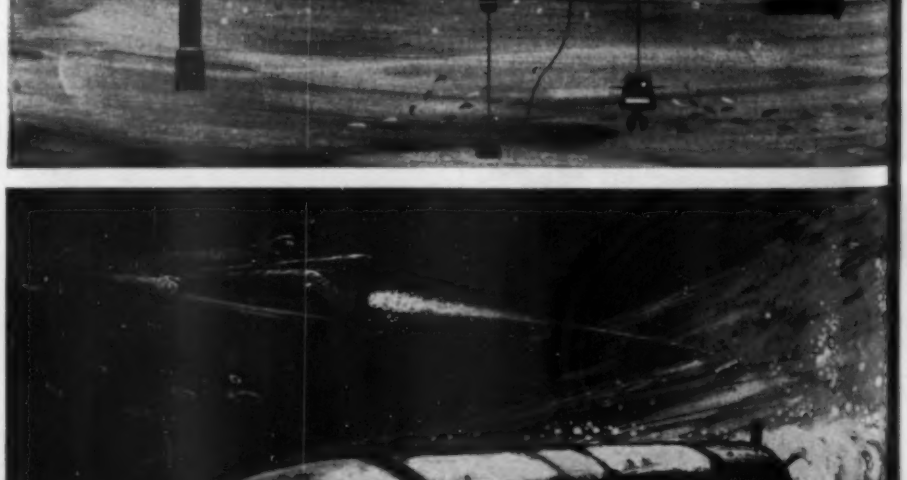
THE WONDER MATERIAL FOR ASW IS PLASTICS

...AND THE COMPANY FOR PLASTICS IS ZENITH







Plastics will not corrode. It will not undergo electrolysis. It is non-magnetic. It is more difficult to detect. And reinforced-plastics has an amazing strength, even at great depths.

Zenith has the extensive engineering knowledge, well-equipped reinforced-plastics laboratories, electronic test facilities, and large production capabilities to form resin-bonded glass fiber into virtually any marine component imaginable. Zenith has more than 15 years experience in pioneering new techniques and production processes in plastics.

Zenith has developed its own method of end-over-end filament winding, a process which gives a high strength-to-weight ratio. Zenith has equipment which makes it possible to mold reinforced plastics into huge and highly complex shapes. These are the reasons Zenith has the versatile capability to produce marine components *better* in plastics. This is why Zenith was the company called on to build the first all-plastics LCVP for the Navy.

Consider the many benefits of plastics in your undersea, ASW, and marine projects before you seal the design. Remember, the wonder material for ASW is plastics...and the company for plastics is Zenith.

Minnesota Mining and Manufacturing Company

ZENITH PLASTICS DIVISION

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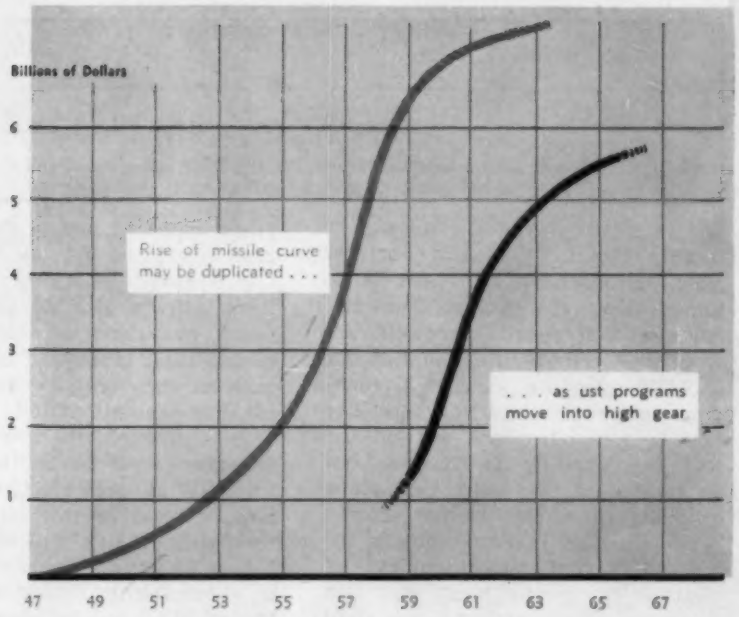
undersea technology

Vol. 2, No. 3 May/June 1961



ust market

$4 billion & rising

FACT **Total ASW spending goes from $1.4 billion in FY-61 to $1.9 billion in FY-62. ASW research and development goes from $240 million in FY-61 to $275 million in FY-62. Oceanography goes from $55 million in FY-61 to $97 million in FY-62. FY-61-62 POLARIS spending goes from $2,876.3 million under Eisenhower to $4,146.4 million under Kennedy.**

FORECAST **POLARIS will peak at $2,600 million in FY-63 and level off around $1,500 million in FY-65. Oceanography will rise to $200 million in FY-63; to $500 million in FY-65. ASW research and development will rise to $500 million in FY-65. Total ASW spending will top $3.5 billion in FY-65 . . . by then commercial market will be important.**

IF YOU WANT TO KNOW about the undersea technology market today, think back to the missile/space market of 1956-57. The same basic situation is extant, and the same basic follow-on developments will occur in much the same manner and for many of the same reasons.

There are those who are convinced we should start now with an all-out assault on the ocean's depths —from the commercial as well as the scientific and military viewpoints. There are others, however, who feel our pace requires only slight acceleration. They're in the majority.

Sound familiar?

We know the Russians have more submarines (400 compared to a little over 100) than we do. We're fairly certain some can fire long-range nuclear warheaded bombardment missiles, and we get disturbing reports that they are moving up on us in the nuclear submarine race. We know they are putting out somewhere between four and ten times the oceanographic research effort that we are and have been ever since World War II. "But we are confident that we are substantially ahead in the inner space race."

Sound familiar?

A few people—old time submariners, incidentally—have urged for years that the submarine is the best ASW weapon there is. Recently a few more have joined their ranks, but the majority still feels that surface vessels, aircraft, hunter-killer forces, etc., are the best answer to the Red U-boat menace.

Anyone around old enough to recall the old manned aircraft vs. missiles scrap, and the way—a few weeks before SPUTNIK I slammed into orbit—one military Service put out an official directive forbidding its personnel to use the word "space"?

Actually our reluctant dive into the deep is starting out on a somewhat better basis than did our American missile effort. After all, the taste of one bitter space defeat pill hardly disappears before we're force-fed another. And besides, the oceans are right down here on Earth and much easier to contemplate . . . and fear, for there are but few of us who do not recall the terrible toll wrought by undersea craft in the two great wars of the first half of the 20th Century. Importantly, however, sufficient of the parameters are similar to justify drawing close comparison as a primary basis for analysis.

In the case of missiles and space we knew which technological disciplines to apply. Our problems were mainly concerned with design and fabrication. In UST in too many cases we know neither which disciplines to apply nor how. When you hear people talking about a breakthrough in ASW, for example, they don't have in mind a breakthrough in turbopump or hydrophone design — though these are important. *Breakthrough* in UST means discovery of a whole new (and probably unsuspected) phenomenon, or perhaps a completely unique application of an old technology.

For example, there appear to be UHF electromagnetic windows in the ocean. The discovery of the precise nature of these windows would be such a break-through. So would discovery of the engineering principles behind boundry layer control in fish; knowledge of the porpoise's (and the bat's) ultrasonic sounding and ranging capabilities.

Point is: With our present equipment even if we spent twice the money we're now spending on ASW, we still would not field the force we would need to effectively protect our inland cities, coastal areas, or vital overseas shipping from severe decimation by enemy U-boats.

The answer lies not in quantity

NAVY BUDGET REQUESTS

ACCOUNT	1961 ($-billions)	1962 ($-billions)	Increase* ($-billions)
New Obligational Authority	12.6	13.8	1.2
Direct Obligations	13.4	13.6	0.2
Expenditures	11.9	12.5	0.6

*Where obligational authority goes this year, generally speaking the other two catagories go in the year(s) following.

but in quality. And the answer to quality lies in elemental part, at least, in learning all there is to know about the oceans. The discoveries that result therefrom are what will provide the real impetus to UST spending in both government and commercial markets. The key is oceanography — not on the scale employed by the Russians, but on something like twice that scale, or many times our present effort.

Spending on oceanography is increasing, and if the present rate of increase is repeated next year and the year after, perhaps we shall achieve that goal — assuming the Russians don't have the same thing in mind.

Meanwhile, there is a market — a good solid market totalling several billions of dollars—depending on just where you draw the line—for UST systems, products, and services, as the following rundown of current UST budget and technologies shows:

The most important fundamental Navy budget development is that POLARIS will be budgeted in addition to, rather than instead of other Navy requirements. Navy is asking for (and will get at least) $1,060 million for Fiscal Year 1962 new shipbuilding, conversion, and FRAM (Fleet Rehabilitation and Modernization) of ships with ASW missions, compared to $632 million in 1961. Similarly, ASW research and development will go from $240 million this year to $275 million in 1962. In effect, this is added money which, under previous years' budget philosophy, would have been preempted by POLARIS. Now POLARIS gets increased money. So do other Navy requirements. The whole UST budget is increasing on the order of $1 billion — FY-62 over FY-61.

Navy won't say (probably because it can't agree on how to break it out) exactly what total spending is on undersea technology — ASW, PSW, USW. However, according to one arbitrary dollar break-out, total ASW spending in FY-61 comes to $1.4 billion and on the same basis will top $1.9 billion in FY-62. Odds favor a comparable increase in FY-63.

These figures are for *antisubmarine warfare* directly and do not include such things as POLARIS program spending and a great deal of cost accounted for by equipments and systems in direct support of ASW efforts. Nor do they include much *prosubmarine* spending and considerable other UST budget items such as oceanography, hydrography, etc. For example, strictly ASW electronics procurement this year totals something over $25 million. The bill for ASW support electronics is calculated at $115 million. The first total incidentally, will at least double in FY-62 due to heavy increase in shipbuilding, FRAM, etc. Of the 1961 RDT&E budget, something like $60 million went for ASW detection, classification, and localization —in other words ASW electronics, mostly sonar, magnetic devices, or related thereto. This total also increases in FY-62.

During the next fiscal year, the Navy will man 817 ships and 6,995 aircraft. Some 45 per cent of the Navy's ships and 14 per cent of its aircraft are *primarily* involved in ASW. Of the ships, 72 per cent will be of World War II vintage in 1962. By the end of calendar 1963, 50 per cent of the fixed wing aircraft will be six years or more old, if present ordering trends continue.

The new budget calls for 36 new ships, 22 conversions, and 644 new aircraft. POLARIS speed-up calls for construction funds for FBM submarines 15 through 19 and authorization for numbers 20 through 29.

Navy's total R&D request is $1,306 million (at this writing but will probably be increased—namely in ASW areas), compared to $1,319 million in FY-61. POLARIS takes the biggest chunk: $443-million. Most important UST areas of R&D include: Oceanography, underwater acoustics and navigation, materials research, and electromagnetic propagation. Other R&D efforts will include: Solid propellants, improved liquid fuels, guidance, fire control, structures, countermeasures, protection, ballistics, aerodynamics, hydrodynamics.

Basic research is $70 million, compared to $60 million in FY-61. Navy's oceanographic budget is $54.3 million, of which $27.6 million is RDT&E. Of the total, $32 million directly supports the National Oceanographic Program.

Our 817-ship fleet includes 14 attack carriers, nine ASW carriers, 225 destroyer types, five POLARIS submarines, 112 other submarines, and amphibious lift for one-and-one-half Marine division/wing teams. On January 1, 1961, 24 ships, excluding POLARIS subs, and over 1,600 aircraft were capable of firing missiles. Another 45 missile ships have been authorized; 250 more missile aircraft will join the fleet in 1961.

The 36 new ships requested in the FY-62 budget include: Seven guided missile frigates, three nuclear-powered attack and 10 POLARIS submarines, three destroyer escorts, three amphibious docks, one amphibious assault ship, one POLARIS tender, three guided missile destroyer escorts, a combat stores vessel, and three research ships (hydrofoil, oceanographic ships, and a survey ship).

The 22 conversions include 14 destroyers, six submarines, one missile range instrumentation ship, and one major communications relay ship. New obligational authority (NOA) for shipbuilding and conversion totals $2,915 million. Emphasis is heavy on ASW detection, classification, fire control, and kill capability.

NOA for missiles, including drones and related equipment, is $606 million, up from $544 million in FY-61—covers improved SIDEWINDER, BULLPUP, TALOS, TERRIER, TARTAR, SUBROC, and POLARIS.

Aircraft NOA totals $1,586 million for 644 aircraft, including F4H all-weather feighters, P3V *Orion* ASW aircraft, and HSS-2 ASW helicopters.

Navy's FRAM program is being increased from 21 to 31 ships. Under this program Navy expects to modernize 255 ships over the next five years, including 163 destroyer types, 35 submarines, and 57 ASW support craft, carriers, amphibious warfare ships and tenders. To achieve what the Navy considers to be an efficient fleet by 1972, FRAM rate will have to be increased to an annual average of 60 ships.

Specifically ASW: ASW in new ship construction in FY-62 includes seven guided missile frigates at $498.5 million. Armament will include ASROC, bow-mounted long-range sonar, drone ASW helicopters (DASH), and four (each) ASW torpedo launchers.

In addition, there will be three *Thresher* class ASW submarines equipped with bow-mounted long-range sonar and four torpedo tubes for launching torpedoes, rockets (SUBROC), or mines. In addition,

the 10 POLARIS submarines will carry effective ASW armament (sonar, torpedoes, SUBROC). Also, there are three destroyer escort ships ($74 million) to be fitted with long range sonar, DASH, ASROC, and ASW torpedo launchers. Three guided missile escort ships will carry similar ASW armaments.

The hydrofoil research ship at $16-million will evaluate ASW tactical capability of the type (PCH hydrofoil funded in 1960 was for limited operations). The two oceanographic ships ($8.4-million) will conduct basic research applicable to ASW. The $5.2 million survey ship is also for ASW—with particular reference to detailed under-ocean mapping for precision underwater navigation.

Fourteen FRAM conversions of destroyers ($158.2 million) are specifically ASW-including installation of long range sonar (SQS-23), ASROC, two (each) torpedo launchers, and two (each) DASH helicopters, plus spares.

Six submarines to be FRAMmed (at $27.9 million) will have their hulls lengthened 15 feet to accommodate improved passive and active sonar, wire-guided torpedoes (ASTOR) and ECM gear. All new submarine building and conversions will be capable of being armed with SUBROC once it becomes available.

Looking ahead to FY-63, Navy has asked for $26.7 million for advanced procurement items for 14 more destroyers under the FRAM program (ASW, communications, electrical components) and $6.8 million for seven more submarine conversions (fire control, other electronics).

Says BuShips Chief Rear Admiral Ralph K. James: "We must strive to design ships which have sufficient potential for modification." He also stresses need for providing ships and their equipment with greater protection from shock and (for submarines) greater hull strength. He also reports that the new pressure fired boilers for surface ships give them a chance, at last, to be able to outrun submerged submarines (speeds reported at over 40 knots).

Major progress in ASW last year: New sonar approved for service use; Grumman ASW aircraft, *Tracker*, accepted for carrier use; Sikorsky HSS-2 helicopter accepted for operational evaluation; new, deep-diving, more silent *Thresher* submarine is being commissioned; fleet delivery of new ASW torpedoes began; new oceanographic studies were started.

Highlights of major efforts upcoming: improvement of variable depth sonar (for detection below the thermal layers) to achieve ranges comparable with those of new bow-mounted sonar; "new sonar" for even greater ranges; improvement of ASW weapon range to at least match that of target detection gear; SUBROC completion; new homing type guidance for long-range ASW torpedo; oceanography.

POLARIS

The button has been pushed launching the POLARIS Fleet Ballistic Missile System to a one-FBM-submarine - per - month deployment rate, starting early in Fiscal Year 1963. POLARIS NOA in FY-61 (this year) rounds out at $1,992.6 million. Total request for FY-62 is $2,153.8 million, including 10 SS(B)N's at $100-million each, plus approximately 200 POLARIS missiles at $1 million each. In FY-63 SS(B)N procurement will be at a rate of one per month plus over 200 missiles a year.

FY-63 should be the peak POLARIS budget year (at around $2,600 million), after which it will taper off to a maintenance rate of around $1,500 million (1960 dollars). Total cost of reaching a 45-boat capability is about $9,000 million, of which approximately one quarter is for research and development. Before the recent increase in authorized practice and training firings, total number of missiles required (including 720 installed in their firing tubes) in achieving this goal was estimated at 1,005. Missiles will have to be replaced approximately every five years (means about a 200 missiles per year procurement rate for as long as the system is operational); submarines, after "over 15" years.

If President Kennedy's POLARIS offer to NATO goes through, this could mean a material increase in this program — or it could simply mean shared control over the fleet already programmed.

OCEANOGRAPHY

At a minimum, U.S. government spending on oceanographic research will top $1 billion over the next decade. Budgetary drifting along in this field is coming to a sudden halt. In Fiscal Year 1960, we spent $46-million; in FY-61 $55 million; and in FY-62 appropriation requests for seven government agencies exceed $97 million. As we learn more of what we can (and should) spend money on, this figure will rise rapidly. It could top $500-million a year by FY-65. For example, 18 months ago the National Science Foundation was trying hard to get a 10-year, $100-million program approved.

In order of diminishing budgetary importance here are the government agencies involved in oceanography: Defense Department, Commerce Department, Interior Department, National Science Foundation, Atomic Energy Commission, Health, Education, and Welfare Department, and the Treasury Department. Getting the most money is research — followed in order by ship construction, surveys, facilities, and an oceanographic data center.★

OCEANOGRAPHIC EQUIPMENT NEEDS

Measuring Instruments

- Wave gauges
- Current meters
- Direct density meters
- Turbulence meter
- Radioactivity devices
- Biological sampling instruments
- Precision salinometers
- Magnetometers

Buoys

- Moored ambient noise monitoring buoys
- Manned and unmanned for continuous recording

Communications

- Acoustical telemetering devices
- Echo sounders
- Deep sea underwater cameras
- Sea floor television systems
- Sea surface analyzers
- Hydrophotometers
- Seismic equipment
- Sound velocity meters
- Sea floor geothermal probes
- Gravimeters
- Automatic continuous plankton samplers
- Audio/visual surveillance systems (monitor sources of marine biological noises)
- Remote sensing and recording systems

Navigation

- Vessel positioning equipment
- Navigation location transponders

Vessels

- Ships for research, surveys, marine resources, conservation & development
- Submersibles (bathyscaphs, mesoschaphs, etc.)
- Modified icebreakers
- Improved midwater trawls
- Infrared radiation thermometers
- Shipboard gamma ray detectors
- Air wind measuring equipment (for moving vessels)
- Automatic meteorological stations

Facilities

- Research laboratories
- Oceanaria
- Instrumented marine towers

why mohole?

Project Mohole, in its way, has every bit the scientific significance of the world's first artificial satellite of earth. Not only is it probing a part of our planet never before sampled by man, but it is supporting the development of many equipments and techniques of real near-term significance to commerce and industry.

It is worth the effort purely from the point of view of the quest for knowledge. Dividends will be in the form of improved ability to work in great depths of water. This could speed the day of ocean-floor mining, deep sea oil drilling, and practical construction techniques—as well as pave way for more scientific exploration.

IN THE BEGINNING it was an idea for lively discussion at a wine breakfast in March, 1957, at Walter Munk's home in La Jolla, Calif. The University of California oceanographer had led the conversation around to the need for a geophysical program as basic as the space exploration projects then being proposed.

Gordon Lill from the Office of Naval Research's Geophysics Branch was promptly named chairman of what was to become Project MOHOLE — a bore-hole to the earth's mantle. Breakfasters were members of the American Miscellaneous Society (AMSOC), which was founded in 1952 as a satire on the propensity of scientists to alphabetize their activities. With no constitution or membership roll, the group was obviously well suited for such a vague project as MOHOLE. Today it occupies rooms on the eighth floor of the shiny, new American Chemical Society building in Washington (you must sign in and out of the building), and, complete with an attractive receptionist, is a formal committee of the National Academy of Sciences — National Research Council. You might say that it happens to the best of us!

Where it all begins: Miles below diamond drill cuts into ocean floor.

From the wine breakfast to the suite of rooms in Washington required money, and that came from the National Science Foundation and the Navy. Willard Bascom, an original member of AMSOC, is project director. Other original members include Prof. Munk and Mr. Lill, Prof. Maurice Ewing, Dr. William Heroy, Prof. Harry Hess, Dr. Harry Ladd, Dr. Arthur Maxwell, Prof. Roger Revelle, Dr. William Rubey, and Dr. Joshua Tracey.

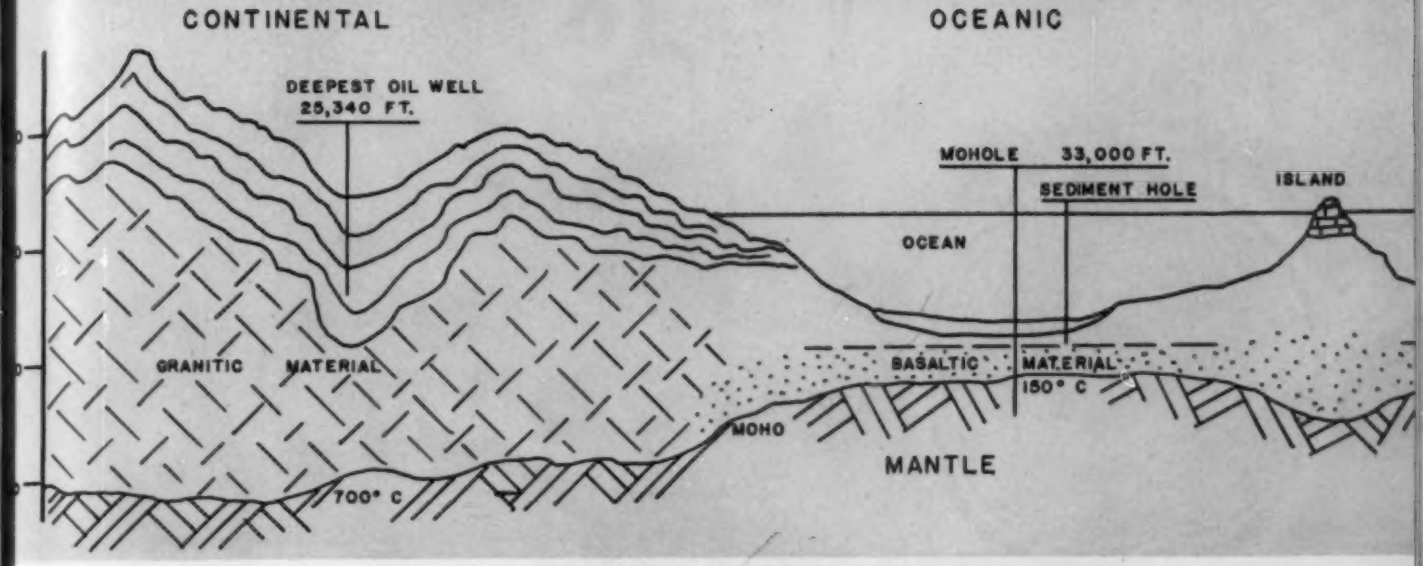
Prof. A. Mohorovicic of Yugoslavia is given credit for first describing the seismic discontinuity between the crust and the mantle of the earth. If the earth could be peeled like an onion, four major zones would be encountered: The crust averaging ten miles in thickness; an 1,800-mile thick mantle of dense rock; the outer core, which is 1,360-mile thick mass of molten material; and the inner core, a mass of solid material 815 miles thick. Project MOHOLE is simply an attempt to drill through the crust to obtain samples of the mantle. Because the crust is thinner beneath the oceans than the continents, the decision was made to drill through the ocean floor.

In the first phase the remodeled seagoing barge CUSS I drilled 18 miles off San Diego at least 750 feet below the ocean bottom from the surface of the sea 3,000 feet above. That was the first step in the project in March which will take another not-yet-designed ship to one of four places on the globe to drill perhaps 18,000 feet beneath the ocean bottom from a perch on the surface three miles above. That day is at least two years away.

Later drillings by the CUSS I were in water up to 12,250 feet deep close by Guadalupe Island off the coast of Baja, Calif. Holes were drilled 110 feet, 234 feet, 560 feet, and 601 feet into the ocean floor. Mr. Bascom returned to Washington in April with several chunks of basalt taken from the 600 foot depth.

The four sites for MOHOLE: In the Pacific, Guadalupe Island and Clipperton Island; in the Atlantic, the Bermuda Rise and north of Puerto Rico. Selection of the exact site is a matter of balancing the need for the maximum possible amount of scientific information against the practical problems of operating the drill ship. Depths to the MOHOLE range from 28,100 feet at Clipperton to 35,500 feet at Guadalupe.

San Diego and Guadalupe tests were 100 per cent successful in both engineering and scientific terms. CUSS I is operated by the Global Marine Exploration Co. of Los Angeles. Fossils have been obtained which range in age from 11,000 years to one million years. The earth's temperature has been taken at 150 feet below the ocean's bottom and found to be about 45 degrees F. (At the ocean floor the temperature is slightly above freezing.) Deep ocean currents at 1,500 feet below



Crust of the earth and location of the moho discontinuity.

the surface have been calculated at running just 0.2 knot.

The most specific reward for underwater engineering to come from MOHOLE: Oceanographers and naval engineers concerned with deep water ship operations will be able to make use of the devices and capabilities developed for sensing position accurately, for holding a ship on station within narrow limits, and for handling weights on the sea floor many times heavier than has previously been possible.

The Navy comments on its support of MOHOLE: Samples of material deposited on the ocean floor since prehistoric time will give it information on the history of the ocean, its currents, temperatures, life, and chemistry.

If it's not enough to show these interests in MOHOLE as reason for the project's existence, then regard Sen. Warren G. Magnuson's (Dem., Wash.) warning that the Russians are engaged in similar work. He reports Soviet scientists will drill in Kamchatka, the Aldan Basin, or Ya-Kutsia (all in northeastern Siberia). The earth's crust in those areas varies from four to 40 miles in thickness. The senator says the Soviets prefer to drill on land because "they are dubious of their ability to drill in deep ocean waters." A cooperative program has been suggested by the Russians for drilling off Puerto Rico (although they have not suggested the U.S. help them drill in Siberia).

Instrumentation — Most of the planned measurements in the hole (or holes) are standard measurements used in the oil industry. Geophysical measurements will be logged in the hole from top to bottom, then correlated with physical properties determined by cores taken from the hole. Seven electric logging sondes will be lowered to investigate the velocity of sound waves in the sediments; the density, porosity, and permeability of the rocks; nautral radiation from the sediments; back-scatter of gamma radiation from a radioactive source lowered into the holes; spontaneous potential and resistivity of the sediments; strength and direction of the earth's magnetic field; magnetic minerals contained in the sediments; temperatures of the layers and their heat conductivity; and the presence of hydrocarbons.

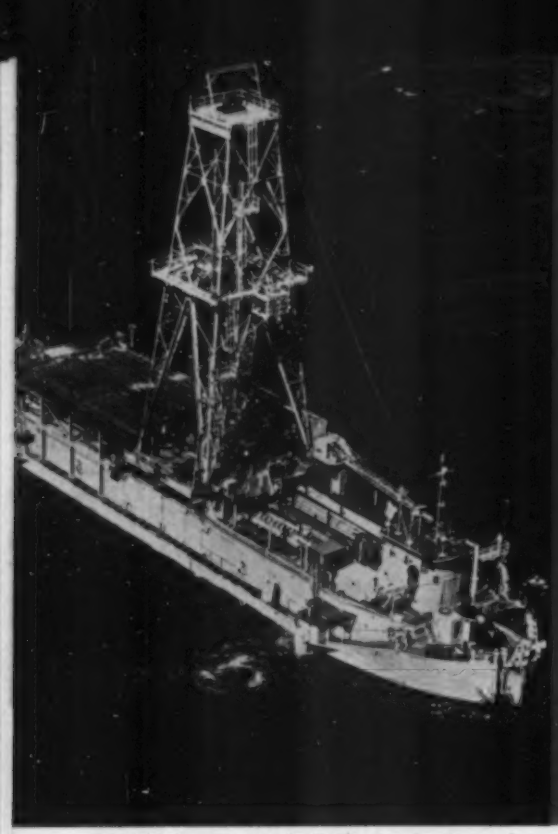
Punch coring will provide the first samples of the bottom oozes. Their water content will be measured, the presence of hydrogen and metallic ions determined, the existence of organic compounds tested for. Mineral grains recovered from first layer cores will include feldspar, volcanic glass, minor and trace elements, and clay.

Clay may be the clue to the rate of sediment deposition on the ocean floor, one of the foremost puzzles for earth scientists. Once the rate is known we may learn whether the oceans are as ancient as generally believed (a billion years old?) or a mere 100 million years old, having been formed by some catastrophic event relatively late in the earth's lifetime.

Some of the scientific questions to be answered appear to have definite bearing on the present state of the art of anti-submarine warfare, particularly in areas of interest like unsound methods of locating submarines. The existence of an unsuspected radioactive heat source high in the mantle or convection currents within the mantle could explain the far too high (in theory) heat flow through the ocean floor, for example. And we could conceivably learn that shifts in the location of the earth's magnetic poles may also be recorded in the orientation of magnetic particles in sediments.

Ship Positioning — The drilling will be through thousands of feet of basalt or an equally hard igneous rock, but the first engineering problem to overcome is that of positioning of the drill ship. The first experiments off San Diego and Guadalupe are described as "as conserva-

AMSOC members Dr. J. Tracey, Dr. R. Revelle, A. Luninski and W. Bascom.



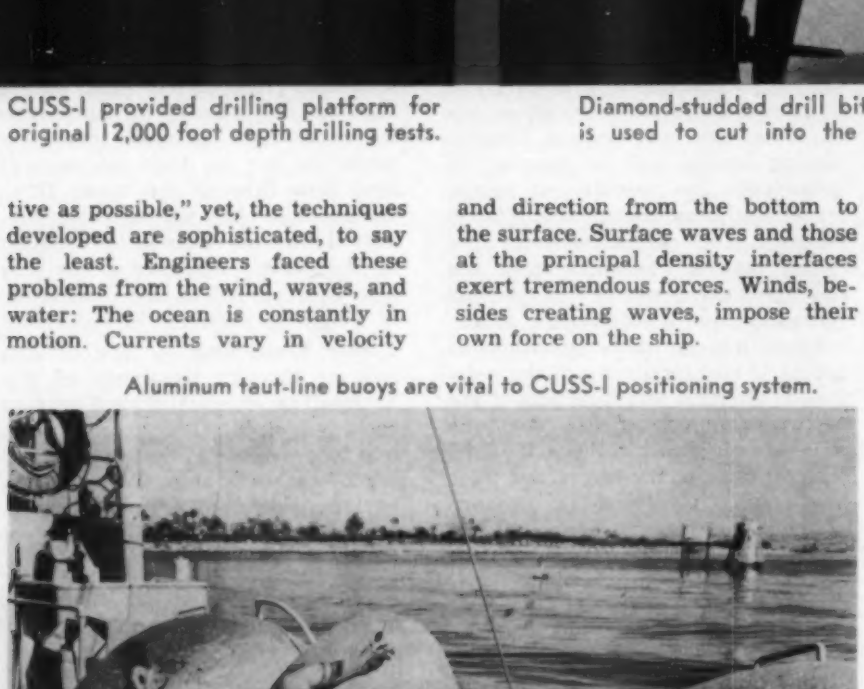
CUSS-I provided drilling platform for original 12,000 foot depth drilling tests.

Diamond-studded drill bit such as this is used to cut into the ocean floor.

Shoe which g pipe pered to a itch a

tive as possible," yet, the techniques developed are sophisticated, to say the least. Engineers faced these problems from the wind, waves, and water: The ocean is constantly in motion. Currents vary in velocity and direction from the bottom to the surface. Surface waves and those at the principal density interfaces exert tremendous forces. Winds, besides creating waves, impose their own force on the ship.

Aluminum taut-line buoys are vital to CUSS-I positioning system.

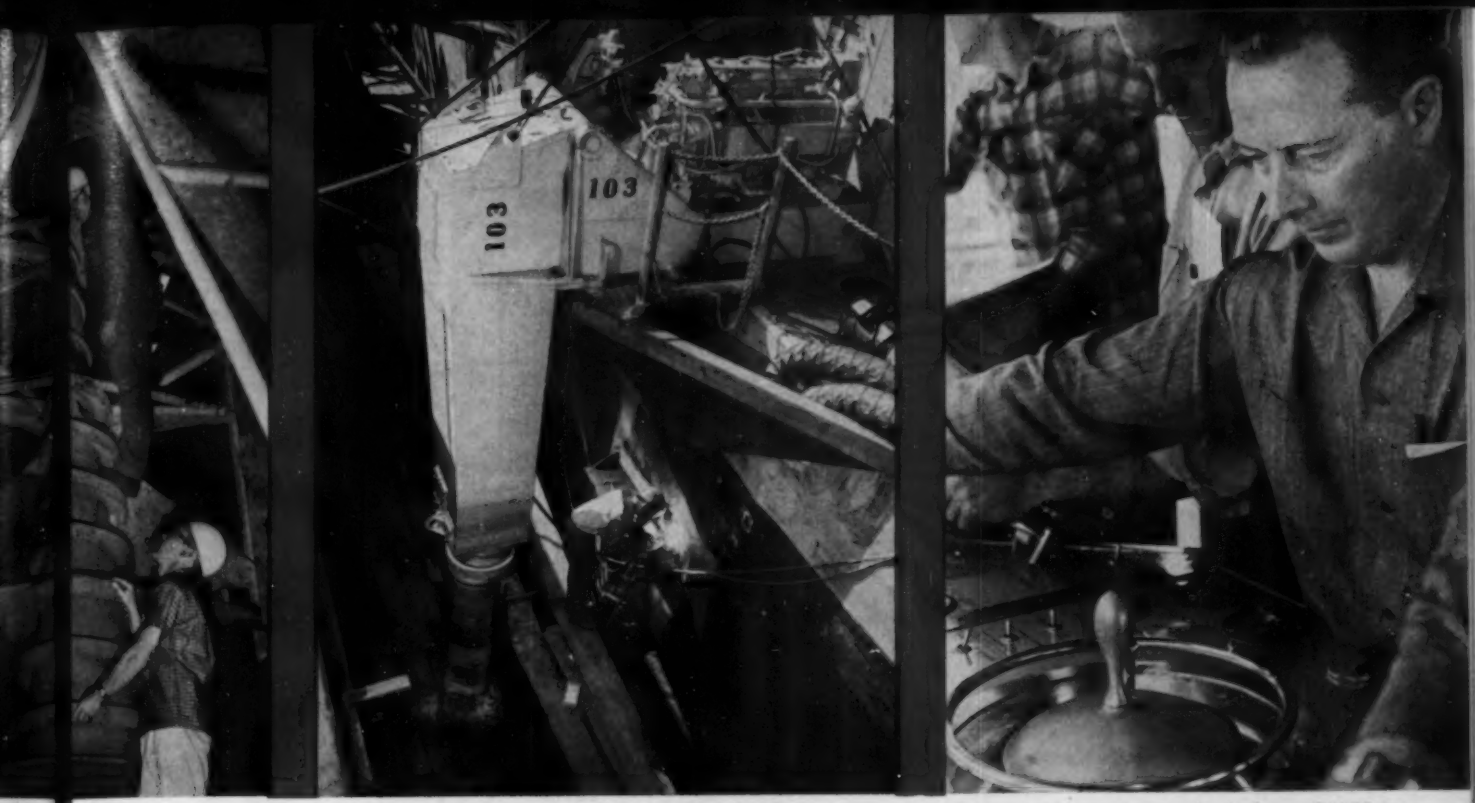


CUSS I has a waterline length of 260 feet, a beam of 48 feet, and a depth to the main deck of 15 feet. When loaded for drilling she displaces 2,900 tons with her 98 foot, heavy duty drilling derrick, automatic pipe racks, and 9,000 feet of drill pipe.

The freedom of CUSS I to leave its station under bad weather conditions points up the difficulty its specially designed successor will have at MOHOLE, where the necessity to return to the same hole is obvious. CUSS I need not remain on station when winds exceed 20 knots, waves exceed six feet in height, surface currents are in excess of 0.5 knots or deep currents are more than 0.2 knots. Guadalupe seldom exceeds these conditions.

The ship positioning system is designed to withstand a force on the order of 12,900 pounds acting at an angle of 70 degrees off the bow. The 4.5 inch diameter drill pipe is like a relatively thin wire when it is extended to great depths. It has been estimated that the ship could drift 600 to 1,000 feet from its center position without stressing the drill pipe inordinately. However, it was decided to use dynamic ship positioning, rather than a mooring system, because if one of the mooring wires snapped, an opposing force of over 24,000 pounds would immediately be imposed on the ship with possibly disasterous results.

The dynamic positioning system



g pipe is ta-
itch and roll.

Four of these mammoth 2,000 hp diesel outboards hold CUSS-I's position.

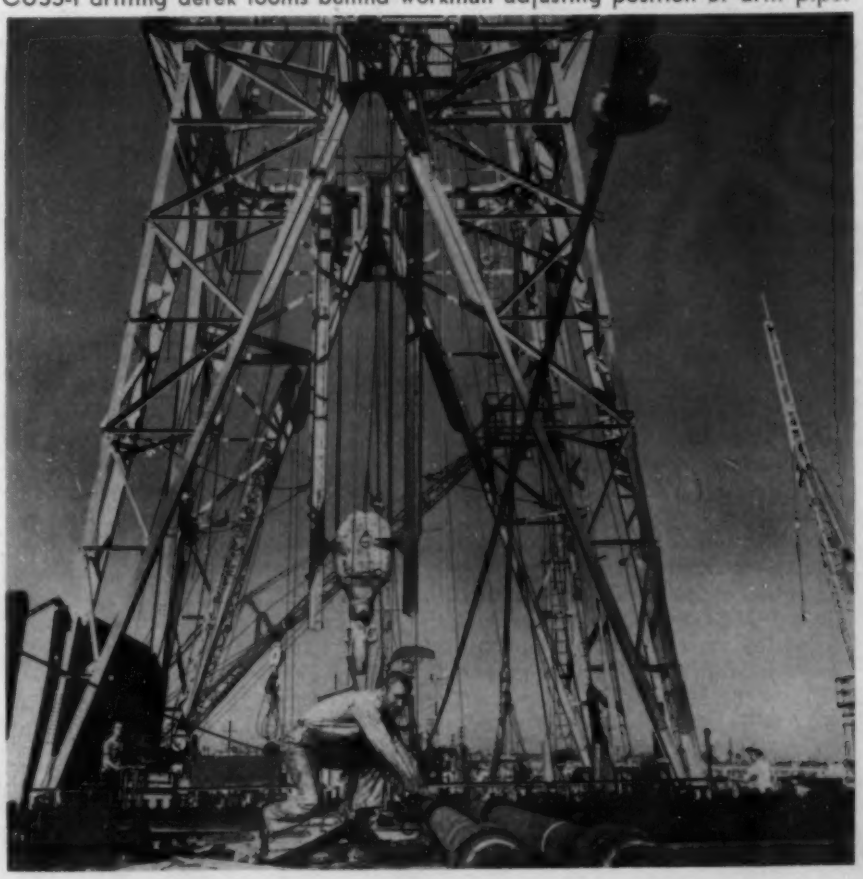
Robert Taggert stands before CUSS-I control console which he developed.

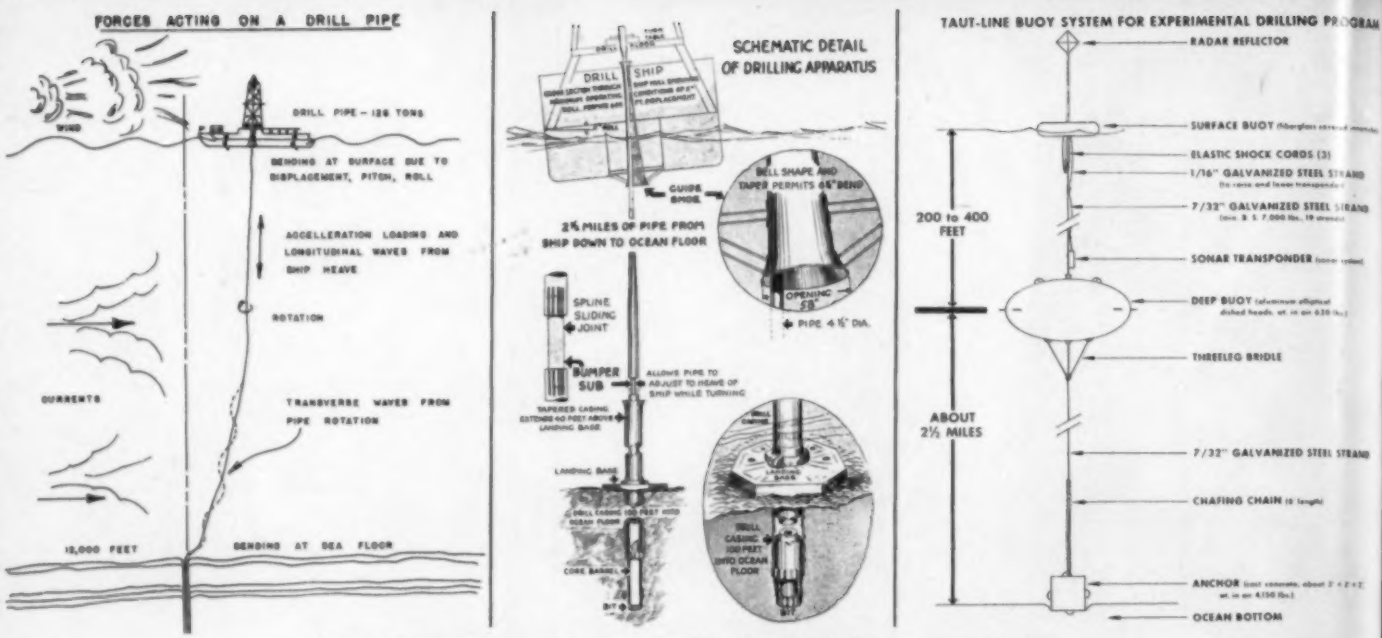
for CUSS I consists of four Murray & Tregurtha "Harbormaster" outboard engines and steering screws. The 200-horsepower diesel units deliver a maximum of 16,000 pounds thrust; they have 16-foot stems and five-foot diameter propellers. They are mounted port and starboard, at the fore and aft extremities of the main deck.

A central control console replaces the four operators which would normally have been required. Each engine has a throttle setting; each propeller has a vertical shaft rotational control. The integrated control assembly consists of a steering wheel and an internally mounted joystick, the stick in turn being mounted on a gimbel assembly. A set of synchro transmitters is geared to the steering wheel. On each gimbel axis a pair of synchro differentials is carried — electrically inserted between the synchro transmitters on the wheel and the slave synchros on the engines.

The synchros' tiny control transmitters, control differentials, and control transformers produce error voltages corresponding to the difference between control position and propeller direction. When the error signals are amplified and their phase sensed, they actuate rotation motor starters which rotate the vertical shafts of the engines until the error signals are reduced to zero. Potentiometers are geared to the steering wheel and to each of the gimbel axes. A voltage is fed through the potentiometers in parallel in such a way that any movement of the controls away from the neutral position increases potentiometer output voltage. This voltage is equivalent to engine tachometer voltages for the engine speed called for by the control setting. Speed is directly controlled by air operated throttle valves which change the governor setting. The valves are controlled

CUSS-I drilling derek looms behind workman adjusting position of drill pipe.





These three diagrams show some of Project Mohole's essential systems.

by small reversible gear motors, which are actuated in one direction or another by the positive (more speed) or negative (less speed) voltage signal until speed matches the control setting.

The pilot at the control console on the ship's bridge simply moves the joystick in the direction desired and the engines respond. He receives his orders from a system of buoys, sonar transponders, and an inclinometer. Several taut line buoys float several hundred feet beneath the surface tethered by a very slim wire rope. Under most conditions they will hold position within 100 feet of a point above their anchors. Attached to some of the buoys are sonar transponders which receive the ping of the ship's sonar and echo it in another frequency to record the exact distance between ship and buoys. The other buoys have a light wire rope leading to the surface where a spar-buoy supports a wire mesh corner radar reflector. The ship's radar constantly scans these reflectors to determine the ship's position independently of the sonar system. An analog inclinometer gives a third method of sensing the ship's position. It is a coaxial cable held in constant tension on the ship, which terminates at an inclinometer fixed to an anchor on the sea floor. The cable is designed as an analog of the drill pipe so that any inclination of the meter at its bottom represents a bending of the pipe where it enters the bottom.

Robert Taggart of Robert Taggart Inc., Falls Church, Va., the designer of the dynamic ship positioning system, concludes an even more precise system can be invented for the MOHOLE. Perhaps the radar and sonar presentations of the ring of buoys around the ship can be fed directly into the control system, eliminating the need for the pilot. Mr. Taggart suggests applications of the system beyond MOHOLE: Other types of oceanographic vessels, floating cranes and dredges, perhaps ground effect machines.

Drilling — Arthur Lubinski, Pan American Petroleum Corp., and Jack McClelland, Edward Horton, and Francois Lampietti of the AMSOC staff determined the forces and stresses on the drill pipe. In the present design the 13,500 feet of pipe weighs about 150,000 pounds. A drill ship may bend the pipe in two ways because the derrick tower acts as a huge lever to bend the pipe about the rotary table. Part of the bending is caused by the ship's movement from a point above the hole; part comes from the ship's rolling motion.

Total bending at the rotary table cannot exceed 1.5 degrees, but it is not unusual for a ship to roll five degrees or more. Mr. Horton's answer to the problem is a guide shoe, a fixed, trumpet shaped tube flaring downward 40 feet below the rotary table. Its walls form a curve equivalent to 1.5 degrees of pipe bending, so no matter how far the ship rolls, the pipe remains snug against the guide.

To prevent excessive bending of the pipe at the hole a tapered casing extends 40 feet above the bottom and is designed to flex so that it supports the pipe in a smooth curve within the allowable bending stress. The casing connects to a flat plate which rests on the bottom and is, in turn, attached to an ordinary piece of casing about 200 feet long. The entire mechanism is lowered on the drill pipe; then drilled and jet-washed into the bottom.

Beginning at the top of the drill string, there is 1,500 feet of 20-pounds-per-foot high tensile strength steel (115,000 pounds per square inch); then comes 5,000 feet of 16.6-pound-per-foot grade E steel (75,000 pounds per square inch tensile); then 6,500 feet of 13.2-pounds-per-foot grade E. Drill collars weighing 30,000 pounds hang on the pipe to keep it in tension and reduce the bending at the bottom. A separate section of collars of similar size (7 by 3.5 inches), weighing 5,000 pounds, is used to keep constant weight on the bit. Between the two sets of drill collars are bumper subs, telescoping splines that transmit rotation but allow vertical movement so the sets of collars can act independently. Several bumpers which open and close a total of ten feet allow the bit to rest firmly on the bottom in spite of the heaving motion of the ship.

Beneath the lowest sub is the core barrel tipped with a 9 inch diamond coring bit. The drill string has a minimum internal diameter of 3.5 inches throughout its length because all plans involve wire line coring and logging through the pipe. Christensen Diamond Products designed the family of coring tools under the general guidance of Mr. McClelland. It will be possible to punch cores 10 feet by 2.125 inches, drill cores 20 feet by 2.375 inches, and (using a center plug) drill without coring. A bit releasing sub will permit recording logs to be run out of the end of the internal flush drill string into the open hole beneath.★

10-KW SONAR AMPLIFIER

Use of Transistors Reduces Size, Weight

By Vartan Vartanian
Manager, Airborne Electrical Engineering Section
Submarine Signal Operations
RAYTHEON COMPANY

There is a need in today's military sonar equipments for high-powered transmitters that are reliable, efficient, and of minimum physical size. These requirements have led to the use of transistors in the design of high-power, audio driver amplifiers. Fortunately, the present state of the art in power transistor manufacture has made feasible the design of pulsed audio amplifiers with power ranges up to 10,000 watts.

Aside from the obvious advantages over vacuum tubes in physical characteristics, the use of transistors makes possible tremendous improvements in efficiency. This is due mainly to the operational characteristics of pulsed sonar. The duty cycle is usually small; therefore, the saving in vacuum tube heater power is most significant. In a typical application, the transistor amplifier will operate at better than 50% efficiency whereas the vacuum tube equivalent may have an overall efficiency of less than 1% because of duty cycle. This savings in power and weight makes the use of transistor amplifiers a must in airborne sonar transmitters, and also very attractive for surface ship and submarine sonars.

Production module — One of the first in a family of transistorized power amplifiers designed and developed at Raytheon's Submarine Signal Operations is shown in Figure 1. This amplifier, which is presently in production, is capable of delivering in excess of 1000 watts and weighs under 10 pounds. The modular construction permits stacking of these amplifiers to drive multiple element transducer arrays as used in scanning sonars. This serves the dual purpose of obtaining higher power capabilities and providing an advantageous means for controlling beams by switching at low-input signal levels.

10,000 watt breadboard design — As a further step in the development of higher powered units, the design of a 10,000-watt amplifier was undertaken. Since this amplifier was not designed for a specific application, it was breadboarded and not packaged in any final form. However, the basic design may be easily modified to suit the particular requirements of many sonar applications. The general design goals for this amplifier were:

1) Pulsed power operation at 10,000 watts with pulse lengths of 250 milliseconds and a 10% duty cycle.

2) Operating ambient temperature range of 0° to 55°C.

3) Frequency range as wide as practical for typical applications.

4) Capable of being packaged in less than a one cubic foot volume and weighing under forty pounds.

The circuit configuration chosen was that of a conventional, class B push-pull amplifier. Figure 2 is a schematic diagram of the basic amplifier and Figure 3 shows the finished breadboard with its keying circuit and dummy load.

The output stage consists of forty WX115UD silicon transistors connected in push-pull parallel. Common unbypassed emitter resistors, combined with the favorable beta-vs-collector current characteristic of the transistors, results in satisfactory load sharing by the parallel pairs. Cooling is provided by a blower motor with a capacity of 150 cfm. This limits the maximum temperature rise on the transistor studs and heat sinks to 20°C above ambient.

The upper frequency response is limited to 12,000 cps by the transistor common emitter cutoff frequency. Gain drop-off may be compensated for by means of a conventional lead network at the input; however, operation over 12,000 cps is marginal because of excessive heating in the transistors. Lower frequency response is determined by the physical size of the magnetic components. The output transformer, constructed on a pair of H-19 Hipersil cores and weighing approximately 6.5 pounds, yields good response down to 2000 cps.

Performance Characteristics—Gain and efficiency curves as a function of frequency for the 10-kw driver amplifier are shown in Figure 4. The power output curve would have dropped off above 9000 cps as indi-

Figure 1. 1-kw transistorized power amplifier.

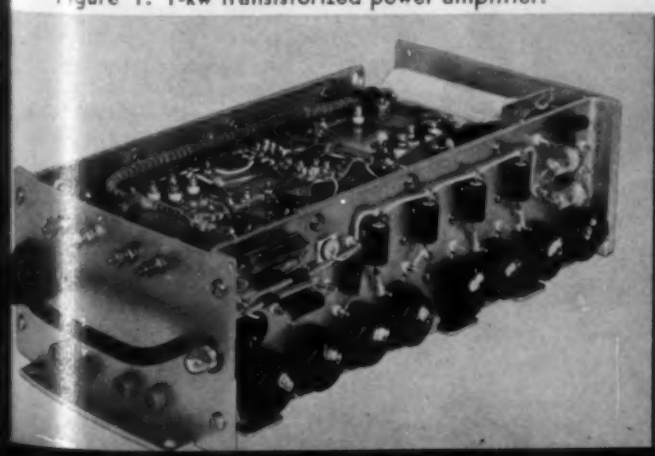
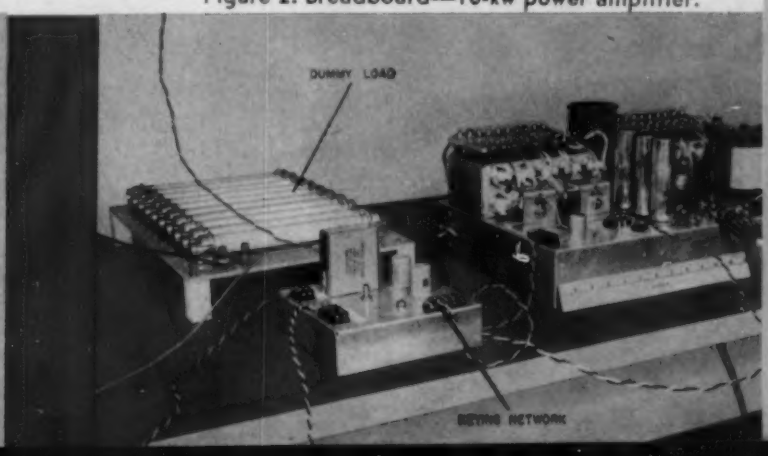


Figure 2. Breadboard—10-kw power amplifier.



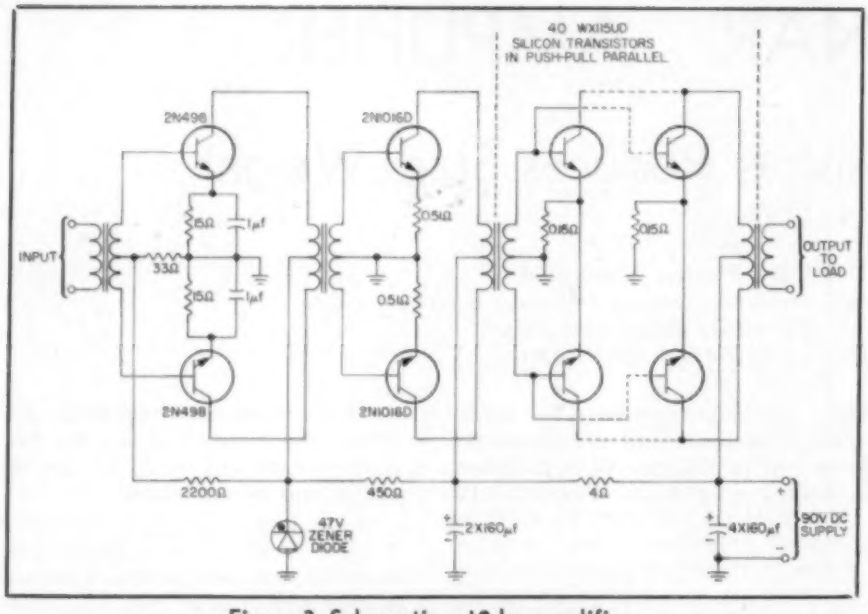


Figure 3. Schematic—10-kw amplifier.

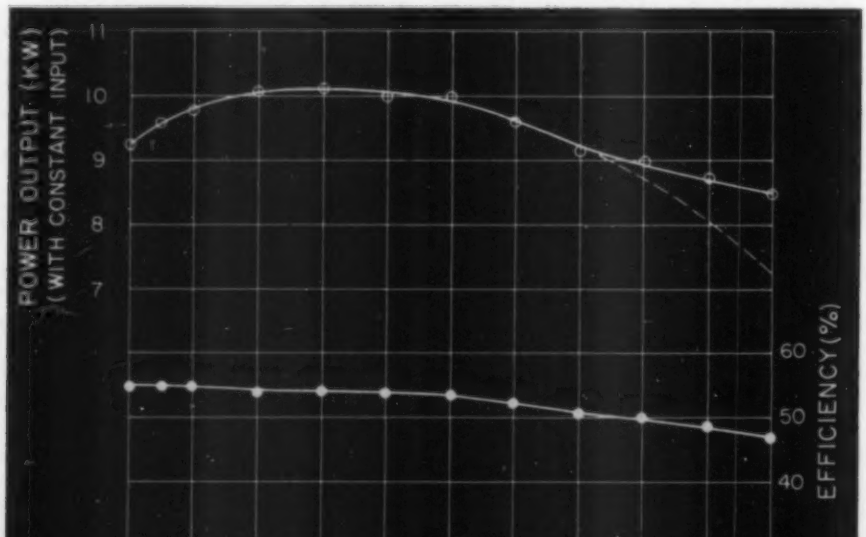


Figure 4. Performance characteristics.

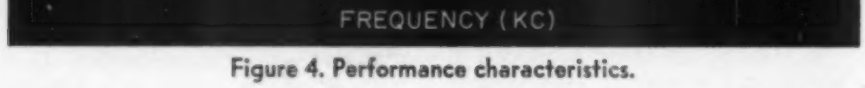


Figure 5. Tuning reactors for 1 and 2-kw loads.

cated by the dotted line if some high-frequency compensation, such as the bypassed 2N498 emitter resistors, was not included. Performance at low and high ambient temperatures is practically identical to the 25°C characteristics shown, hence temperature compensation of the circuits is unnecessary.

Direct-Current Power Sources — The most suitable silicon power transistors commercially available at present, such as the 2N1016D and WX115UD, have maximum collector voltage ratings of 200 volts. Allowing for safety margins, this fixes the power supply voltage at 80 to 90 volts for push-pull amplifier configurations. For a 10-kw amplifier operating at 50% minimum efficiency, current pulses of 250 amperes can be expected. The power source used in testing this breadboard amplifier was a 90-volt storage battery whose terminal voltage dropped to 85 volts during pulses. For operation in the field, the following types of power supplies may be considered:

1) **Capacitive Discharge** — This method has been used successfully in many equipments and has the advantage of reducing peak loads on the primary supply. However, in low-voltage, high-power applications, capacitor size becomes prohibitive if pulse lengths are greater than a few milliseconds. In addition, the regulation is inherently poor, leading to severe amplitude modulation of the pulse.

2) **Storage Battery** — Nicad or silver cell storage batteries afford good regulation with excellent weight to capacity ratios. They are, however, relatively expensive, require maintenance, and generally cannot be charged as rapidly as they can be discharged during active operation of the equipment.

3) **Transformer-Rectifiers** — This type of conventional supply is practical with three-phase a-c primary sources. Full wave rectification yields low ripple, and regulation can be made tolerable with careful design. The main disadvantages are weight, unless a 400-cps primary supply is available, and the large peak loads placed on the primary supply.

4) **Other Sources** — These include rotating d-c generators and sea cells, each of which has its special characteristics and limitations.

Transducer tuning — A critical problem in driving transducer loads is their highly reactive nature. Crystal and ceramic transducers, with clamped capacitive impedances, typically have electrical Q's between 2

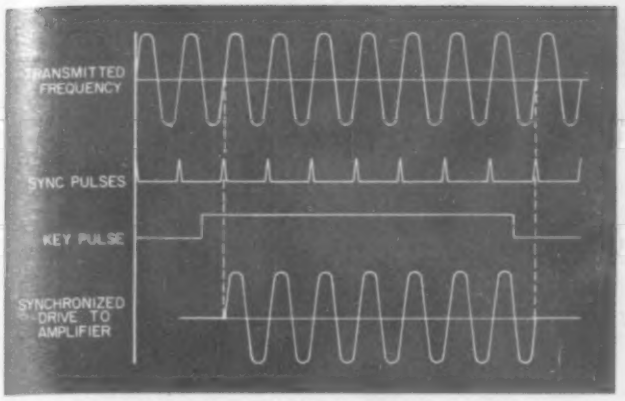


Figure 6. Pulse synchronization.

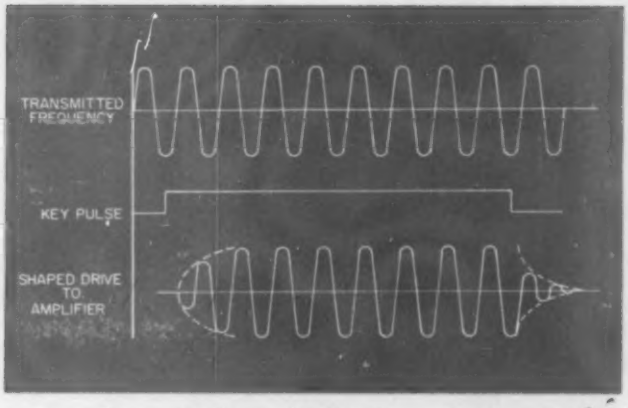


Figure 7. Key pulse-shaping network.

and 20. This places strict accuracy and linearity requirements on the tuning reactors used for power factor correction. The resultant load, as seen by the amplifier, must be resistive at the transmitted frequency. Otherwise, the load line of the power amplifier will be elliptical and result in higher heat dissipation in the transistors.

Typical tuning reactors for use at 1000 to 2000-watt power loads are shown in Figure 5. The reactor cores are toroids of molybdenum permalloy powder construction to insure linearity, stability, and high efficiency. These reactors have electrical Q's greater than 50 and are used for either series or parallel tuning. Taps are provided at ±3% and ±6% of nominal inductance to allow for compensation of transducer reactance variations in production. The tuning reactor is physically located at, or near, the transducer rather than on the amplifier package because the potentials after the reactor are often as high as several thousand volts.

Pulse shaping and synchronized keying — To prevent dangerous transients at the start and finish of transmitter keying, either wave shaping or synchronized keying is necessary. The latter method is effective with tuned loads when the d-c power supply has low internal inductance. As shown in Figure 6, the start and finish of the keyed pulse are synchronized accurately to the sinusoidal transmitted wave form.

Although synchronous keying has been used successfully in many equipments, the method is best applied to vacuum tube circuits with capacitor-discharge type power supplies. In transistorized amplifiers, pulse-shaping circuits such as shown in Figure 7 offer more satisfactory results.

The leading and trailing edges of the keyed transmitter waveform are determined by Q and the R-C combination respectively. Typical resultant waveforms are illustrated in Figure 8.

Shown in Figure 9 are waveforms across a tuned transducer load being driven by an amplifier with and without pulse shaping on the input signal. The transient spikes with the unshaped pulse reflect back to the primary of the output transformer, increasing the probability of failure in the output transistors.

Future Development — An increase in the use of transistors in high-power sonar transmitters is assured not only by the success to date, but also by industry's record of improvement in transistor design and manufacture. As higher power, more reliable transistors are made available, and prices are reduced, the advantages of transistorized designs will increase.

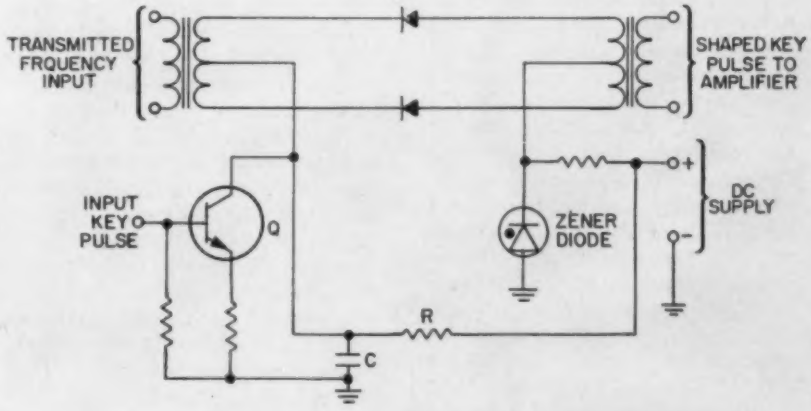


Figure 8. Pulse shaping.

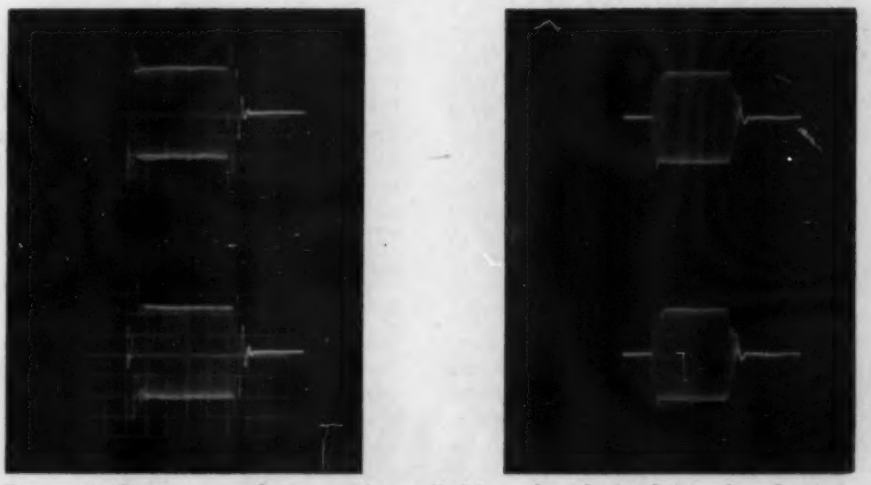


Figure 9. Output waveforms: without (left) and with (right) pulse shaping.

saclant asw center

By Kenneth M. Gentry

Flag ceremony at commissioning of SACLANT, May, 1959.

Shortly after Russia announced its first successful Sputnik launching there was a meeting of the NATO Heads of State in Paris in December, 1957, at which President Eisenhower called for increased scientific cooperation between the allies. As a result of this and other planning, a subcommittee of the Naval Research Advisory Committee (NRAC) went to Europe in May, 1958, at the request of the Chief of Naval Operations (CNO) and the Supreme Allied Commander Atlantic (SACLANT), to investigate the establishment of an ASW research center in Europe for the purpose of pooling the technical data and scientific personnel of selected NATO nations in an effort to solve some of the ASW problems which none of these nations had been able to solve independently.

The sub-committee, of which I was Chairman, visited seven countries (England, France, Germany, Holland, Denmark, Norway and Italy), and talked with the top naval and scientific leaders in each. The enthusiastic reception of the idea and the constructive suggestions made during these visits led the sub-committee to recommend that an ASW research center employing naval and scientific personnel from the seven countries visited plus Canada and the United States be established in La Spezia, Italy. The U.S. Department of Defense (DOD) agreed to finance the initial establishment and operation of The Center and the Raytheon Co. was selected by the DOD to staff and manage it.* On May 2, 1959, less than a year later, The Center was officially commissioned — a record in international negotiations.

Why La Spezia, someone may ask. There are several good reasons, such as: the large Italian R & D establishment located in the same compound as the building where The Center would be located; a big Italian naval base, shipyard and inner anchorage; a sea plane base; the training school for Italian "frogmen"; an above and below water torpedo test range; and a gun firing range. The deciding one, however, was the offer of the Italian Government to provide a fine two story building with 34,000 sq. ft. of space, plus the services of external and internal security guards.

The mission of The Center is "to provide technical advice and assistance to SACLANT and other NATO Commanders and participating nations in the field of ASW" by conducting research and limited development work. A Scientific Advisory Council, composed of an eminent scientist from each nation, plus the Military and Scientific Directors of the Center, provide scientific advice and recommendations to SACLANT, including its opinion of the scientific program. This program is prepared by the Scientific Staff with the assistance, as necessary, of the Military Staff.

The small Military Staff at The Center is composed of seagoing officers selected in rotation from the participating nations, with a pre-ponderance of U.S. Naval officers during the period of U.S. funding. This Staff serves two main purposes, namely: (1) Provision of operational advice and assistance to the scientists; and (2) fiscal monitoring of the management contract.

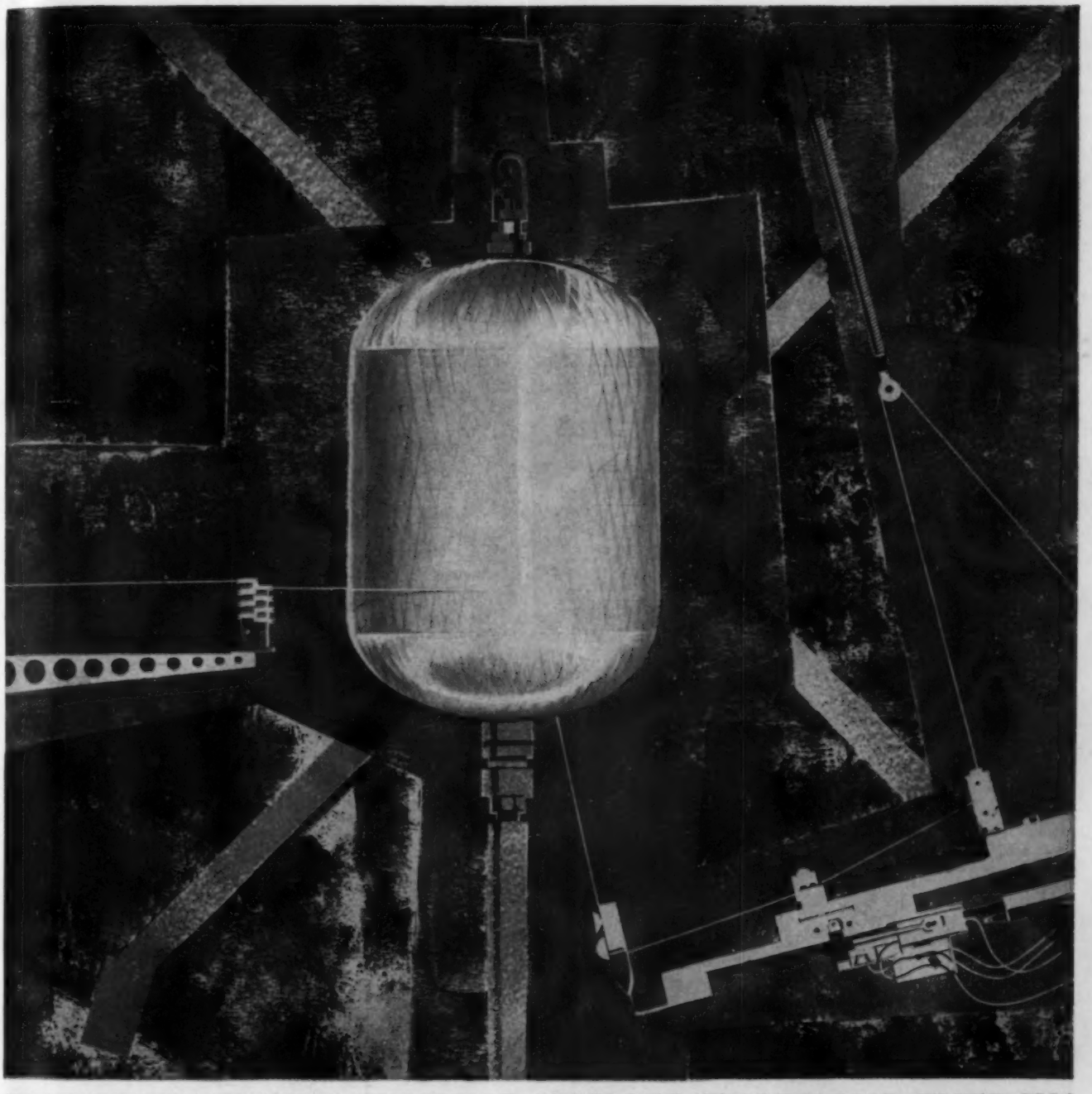
The Scientific Staff is composed of some 28 senior scientists divided into three research groups: Oceanography, applied research and operational research and analysis. These senior scientists are well distributed among the nine participating nations and most of them have a PhD and five years' experience in their discipline.

The Center has very well equipped electrical and electronic shops, a small machine shop (with a large and complete Italian Navy machine shop available across the street) and a Sperry-Rand **Atlas I** digital computer presented and installed by the U.S. DOD. Immediately adjoining the building is a deep water slip which permits ready installation of equipment in boats or small ships for testing alongside the dock or taking to sea. In April of 1960 The Center charter-hired a 2000-ton Italian coastal vessel, the ARAGONESE, and commenced outfitting her as an oceanographic and applied research ship. In June 1960 a diesel-powered air sea rescue craft was made available to The Center by the U.S. Navy. Finally, The Center has a large constantly increasing library of classified technical data in the field of ASW supplied by the participating nations.

Although the detailed projects of the current program are NATO classified, it can be said that most of the work is directed towards the "detection and classification of submarines at sea".

What are the prospects for the future of this laboratory, with its very modest annual budget of approximately $1.5 million and a comparatively small staff? The answer lies in the bringing together, under one roof, of scientists, engineers, technicians and naval officers from various NATO nations with different backgrounds and ideas, and combining their efforts into a single channel. If nothing else is accomplished there will at least be a common understanding of the problems involved and what has already been done to try and solve them. This in itself will prevent unnecessary and costly duplication of effort within NATO.*

Kenneth M. Gentry, a graduate of the U.S. Naval Academy, was chairman of the Naval Research Advisory subcommittee which led to the establishment of the SACLANT Research Center, and during 1959-1960 served as the first Military Director of the Center.



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MAKES YOUR IDEAS *WORK*

hollow core structures for high pressure hulls

By J. D. Stachiw
Pennsylvania State University

Pressure vessels subjected to external pressure have been the object of intensive engineering studies and experimentation for a long time. Since a smooth tube, the commonest form of a pressure vessel, is very susceptible to elastic buckling, various types of stiffeners have been proposed and tried in the last six decades (Figure 1).

Well-known scientists such as Bresse, Bryan, Von Mises, Von Sanden, Gunther, Widenburg, Trilling, Salerno, Donnell, Kendrick, Grigoliuk and others have developed workable theories that relate the collapse pressure of variously stiffened shells to their physical parameters. On the basis of theoretical considerations postulated by some of the authors[6,7] it appears that the circumferentially stiffened sandwich shell represents the optimum design for pressure vessels subjected to external pressure and thus possesses the highest pressure to shell weight ratio.

Collapse Pressure of Circumferentially Stiffened Sandwich Shells — To maximize the resistance to collapse by external pressure the shells have to be designed in such a manner that they possess maximum rigidity at minimum expenditure of construction materials. This goal can be achieved by designing a shell made up of wide flange ring sections joined together at top and bottom flanges. This type of shell construction not only increases the rigidity of the shell in the circumferential direction, where it counts most, but also in the longitudinal direction.

Although Grigoluk[6] has developed analytically a whole set of complicated differential equations describing the strain and collapse pressures in circumferentially stiffened sandwich shells, there exists a relatively simple relationship that will predict quite accurately the overall collapse of these shells. Bresse and Bryan's equation[1,2] for the collapse pressure of long smooth tubes holds equally well for above mentioned sandwich shells if proper modifications of terms in the equation as suggested by the author have been made.

$$p_{cr} = \frac{3E_t I_x}{(1-\mu^2)(R_c)^2 R_o} \qquad (1)$$

p_{cr} = external hydrostatic collapse pressure — psi
E_t = tangential modulus of elasticity — psi
μ = Poisson's ratio
R_c = radius of neutral axis of the sandwich shell wall — inches
R_o = external shell radius — inches
I_x = moment of inertia of the axial cross-section of the sandwich shell wall about its neutral axis — inch⁴/inch of wall length

Implosion Testing of Shells — Before any extensive sandwich shell design and construction program was initiated, it was considered proper to construct an exploratory shell comparison series incorporating the representative types of shell designs described in the literature.

The series consisted of five acrylic resin shells of identical *weight, length, OD* and *ID*. The collapse pressures of the shells differed widely from each other (Table 1), the circumferentially stiffened shell possessing the highest pressure to weight ratio.

With the experimental data from the acrylic resin comparison series confirming the circumferentially stiffened sandwich shell as the best design, two 21-inch diameter shells of same design but metallic construction material were built. Alu-

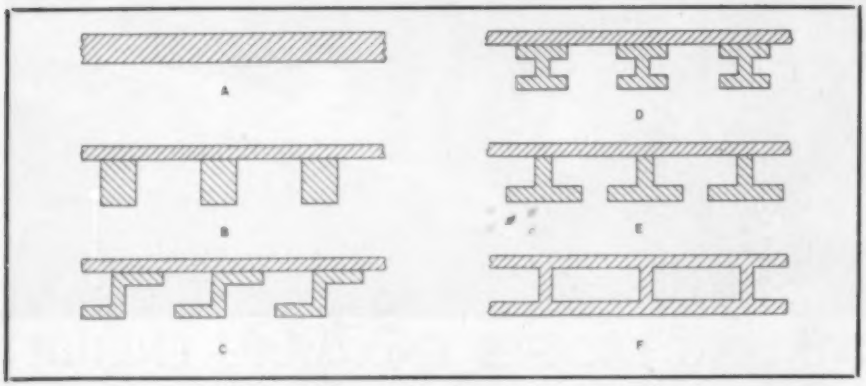

Figure 1. Stiffeners for vessels subjected to external pressure.

TABLE 1

Type	Collapse Pressure	n
Mod. 1 — Smooth Shell	590 psi	.585 x 10^5
Mod. 2 — Smooth Shell With Circumferential Plain Ribs	1200 psi	1.185 x 10^5
Mod. 3 — Smooth Shell With Circumferential T-Ribs	1100 psi	1.09 x 10^5
Mod. 4 — Sandwich Shell With Longitudinal Ribs	1100 psi	1.09 x 10^5
Mod. 5 — Sandwich Shell With Circumferential Ribs	1650 psi	1.635 x 10^5

n = pressure to weight ratio = $p_c V/W$; p_c = collapse pressure—psi; V = shell displacement volume—inch³; W = shell weight—lbs.

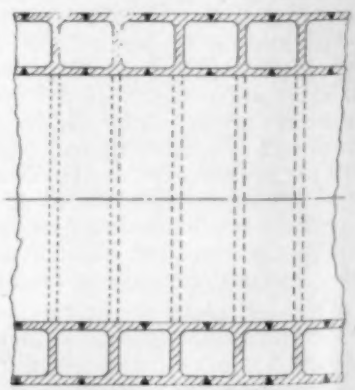

Figure 2. Circumferentially stiffened sandwich shell design, welded wide flange ring construction.

Ocean-bed Bonanza!

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The base of mining operations, pictured above while under construction, consists of a Y-shaped island stretching for nearly one mile and towering more than 60 feet above the water.

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The vital power for this operation pours from huge generators to the drilling platforms through Simplex submarine power cables. Simplex, a working partner of the mining industry for thirty years, is proud to participate in this monumental engineering achievement.

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minum alloy 6061-T6 was chosen for the construction due to its workability, weldability and relatively high material strength/weight ratio.

In view of the small number of pressure vessel shells desired for the testing program, welding of wide flange forged rings was chosen as the most economical method of construction. (Figure 2).

The rough machined rings were joined by sigma process using 4043 filler, heat-treated, and machined to final dimensions. Quality control of high caliber was maintained by the shell fabricator throughout the length of the fabrication process that produced shells with 48,500 psi parent material and 40,500 psi weld strengths.

The pressure vessel, composed of two 21-inch diameter, 33.5-inch long shells instrumented with Sr-4 gages was subjected to gradually increasing external pressure (Figure 3). until collapse of the shell assembly occurred at 2300 psi, giving these shells[4] a pressure to weight ratio of 2.21×10^5. The imploded shells were measured and dissected (Figure 4).

Careful inspection of the annular space failed to detect any buckling of the circumferential stiffeners in the direction perpendicular to their planes, thus confirming the conclusion — already formed on the basis of external shell observations — that no localized buckling of any shell component occurred during the vessel collapse. The shell imploded as a well-designed homogeneous structural unit which it was intended to be. The shells were designed on the basis of Equation 1, the predicted and actual collapse pressures being within 10 per cent.

Before the discussion on implosion testing shells can be concluded, it is well to point out that during the implosion testing of the pressure vessel, the ends of the shells were free to contract and buckle under pressure like the rest of the vessel. Careful inspection of Figure 3 will show that the end adaptor rings, with which the shells were equipped, were free to slide on the well-greased closure plates. Certainly, there was some restraint due to static friction between the end rings and the closure plate, but nothing even remotely approaching the restraint found in simply or rigidly end restrained shells. Thus it can be postulated that the experimental shell collapse pressure observed pertains to very long shells. If the pressure vessel assembly were simply or rigidly end supported, the collapse pressure would have been considerably larger, the collapse pressure increase depending on its L/D ratio. The free sliding end support was selected for the experimental implosion test because it permitted the author to obtain collapse data for long pressure vessels on the basis of a cheap shorter vessel. An experimental approximation to the long pressure vessel was desirable, since Equation 1, used as the basis of this design, applies only to long cylindrical vessels.

Areas for Future Experiments — The experiments described in this article have been strictly of exploratory nature and they have produced only one worthwhile experimental result; the fact that circumferentially stiffened sandwich shells may represent the optimum in pressure to weight ratio for vessels under external pressure, and that their overall collapse pressure can be predicted with astonishing accuracy by the simple relationship of Equation 1.

The selection of proper dimensions for the outer and inner shell skins, circumferential ribs, and the rib spacing is still a complicated problem that has not been properly solved for the whole range of t/D and L/D sandwich shell ratios. Excellent work on theoretical basis has been done in this area by Batdorf[5], Grigoliuk[6], Fulton[7] and is yet awaiting experimental verification

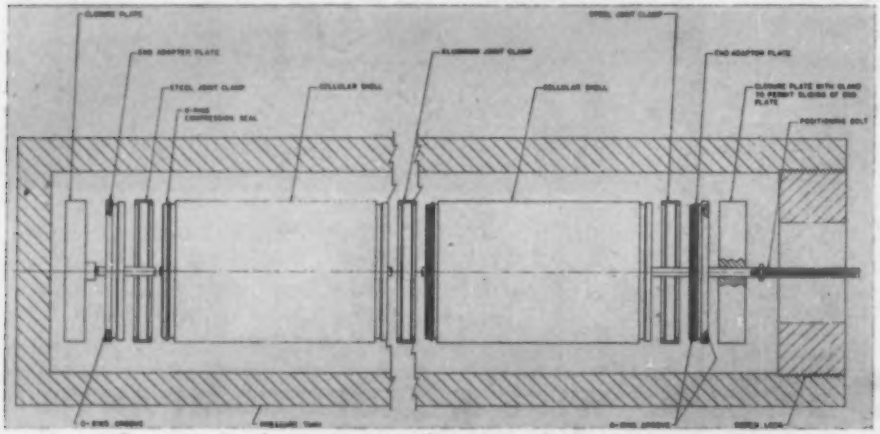

Figure 3. Implosion testing of experimental pressure vessels.

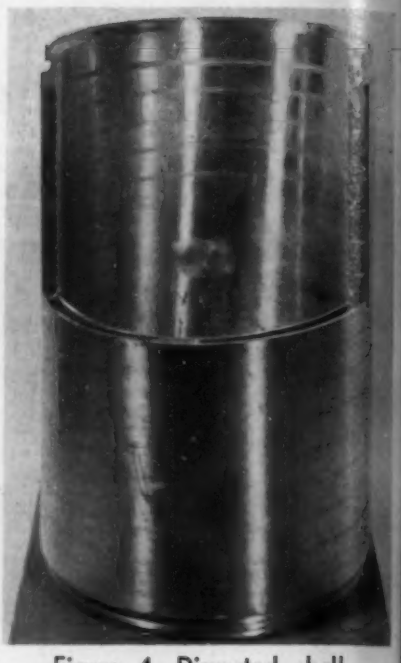

Figure 4. Dissected shell.

by workers in this field.

To improve the cellular shells, further investigations have to be conducted in these general areas:

a) Selection of materials that due to their specific combination of E_t, σ_{ys} and p will give lighter shells for higher external pressures.

b) Combination of wall structural component proportions that avoid local buckling before overall shell collapse occurs.

c) Use of pressurizing medium in annual spaces to increase the local and overall rigidity of the shell.

d) Developing a manufacturing process that will make it feasible to construct sandwich shells cheaply for industrial use.

The author himself has proposed and designed several new sandwich shell configurations using stronger aluminum alloys which he intends to test in the near future.★

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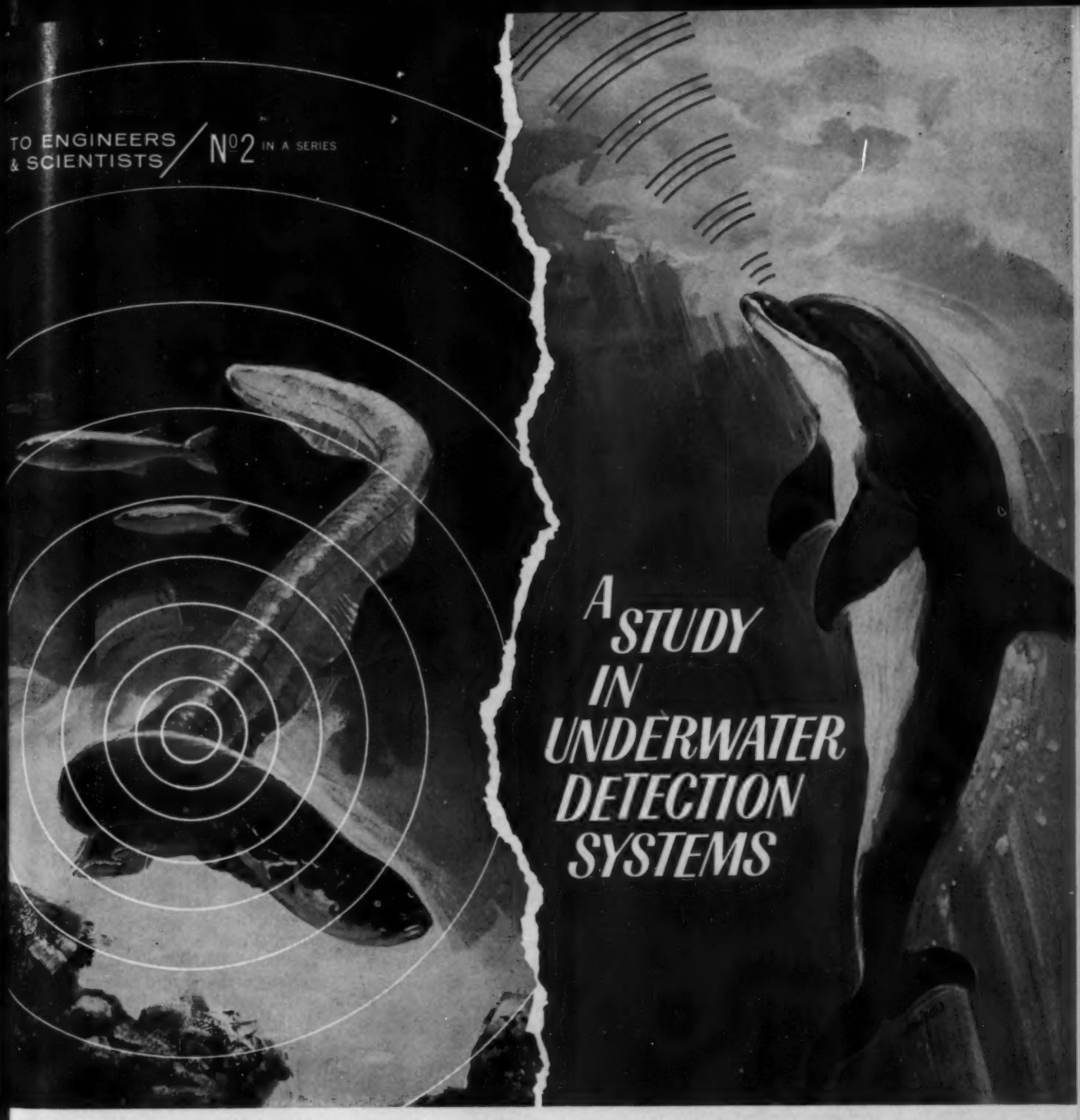
TO ENGINEERS & SCIENTISTS / No 2 IN A SERIES



A STUDY IN UNDERWATER DETECTION SYSTEMS

SE ARRAYS OF SIGNALS — so suggestive of man-made sonar patterns — are indicative of two distinct approaches to underwater detection long employed by ically gifted Pisces and Delphinidae. **Gymnotus carapo** (left) utilizes diphasic emissions of 50-60 pulses/sec. **Tursiops truncatus** (right) utters ultrasonic s, aimed in the specific direction of foes, friends, food or obstructions.

Though many kinds of fish, as well as dolphins, have been operating successful detection systems (electrical and acoustical) long before *Homo sapiens* arrived on the scene, HMED engineers today have surpassed the original inventors of such undersea devices.

Take range. Where *G. carapo* and *T. truncatus* must be satisfied with range measured in feet, HMED engineers think in terms of (classified) miles. Right now they are engaged in creating the AN/SQS-26 Search Sonar System to hunt out vastly larger predators than ever worried fish or porpoise—leviathans with metal skins, displacing thousands of tons, roaming all the oceans.

Or take frequency. Where *T. truncatus* operates at high frequency (in which area he can still teach humans a thing or two) HMED engineers, recognizing the problems imposed by high frequency attenuation of acoustical signals in water, are now developing *low* frequency systems that would make a dolphin flip.

Opportunities are now open for engineers to join HMED on the AN/SQS-26 program; on follow-on versions of the HMED developed sonar systems that successfully detected ice conditions for USS Nautilus on its historic under-the-North Pole voyage; on a new underwater system that will enable man to maintain surveillance on millions of cubic miles of inner space; on other projects in long range underwater detection.

Additional openings exist in the fields of: Missile Guidance and Control; Air Traffic Control; Data Processing & Display; Ground Radars (Fixed and mobile–13,000 ton to jeep size); Marine Radars.

Engineers with experience in any of these areas are invited to write in full confidence to: Mr. G. Callender, Div. 145-BMQ.

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The Pressure Barrier: Marketing Opportunities Stress R&D

By Seabrook Hull

Just how deep our latest operational submarines go is a closely guarded secret. No point in telling a potential enemy how deep he should set his depth charges. But whatever it is, it's not a very great depth as ocean depths go — less, say, than 2,000 feet.

As the artillery man cherishes high ground and as air supremacy depends in part, at least, on who can get on top, so in the realm of the underseas does tactical advantage lie with the submarine that can go deeper. But wanting to go deeper and realizing broad operational versatility at great depths are two different things.

Today's operational nuclear submarine wallows low in the water when surfaced — not so much because this is the ideal situation as because taking the weight of the submarine (particularly its pressure hull) as a whole, this is just about all the buoyancy that can be built into it. Thus, if the pressure hull were to get much thicker, the boats wouldn't float at all.

But pressure hull weight is only one obstacle to going deeper. There are materials problems, construction problems, sealing problems; there are problems of ship shrinkage, of lightening and compacting ship's equipment, and of providing new operational capabilities in what amounts to a new environment.

Concurrently with their creeping assault on the depths, Navy Bureau of Ships, Office of Naval Research, and Bureau of Weapons are trying to leapfrog the pressure barrier — ideally with a submarine which will be as at home on the floor of the oceans' deepest trench as it is ducking, back and forth through the thermocline. However, Navy will be happy if, within the proximate future, it can come up with a fleet of vessels with a maximum depth limitation of on the order of 10,000 feet. Here are some of the problems that must be solved before this goal can be realized.

Pressure hull materials — Submarine pressure hulls constitute primarily an extension of armor plate technology. HY-80 steel (standard pressure hull material) is listed officially as an armor plate material in the industry handbooks. It has a yield strength of from 80,000 to 100,000 psi, depending on section thickness.

Recently, the Navy contracted with Westinghouse Electric Corp. to develop (a) HY-150 and (b) new and better fabrication (mainly welding) techniques. The new material would have a minimum yield strength of 150,000 psi, thus reducing equivalent hull weight by almost a half.

However, there are problems: As the tensile strength of alloy steel goes up, welding becomes more critical — not only in the weld/parent metal interface but in the much broader heat-effected zone as well. There's even talk around the Navy's hallowed halls of "How do you heat treat and stress relieve a submarine?" And, "How do you join plate sections without inducing stress at the joint?"

However, there are bound to be ways. Back during the Korean war the panultimate of mine-sweeping devices was constructed — a monster known as X-MAP. This was a towed structure some 300 feet in length and 30 feet in diameter and constructed of armour plate up to nine inches thick. As a mine sweeping device, it might have been very good except for the fact that it almost invariably ended up a battle as to which was towing which. Point is: Despite plate thickness the welds were 100 per cent secure — which proves that it can be done.

In addition, Navy is investigating materials other than steel for service in deep pressure submarine hulls — including titanium, aluminum, beryllium, plastics, etc. David Taylor Model Basin in recent studies has determined that on a strength-to-weight basis, "titanium alloys of 120,000 psi yield strength can be used advantageously for hulls of deep diving submarines." DTMB tests included study of the weld problem, notch sensitivity, etc., and resulted in the tentative conclusion that the most promising titanium materials are the MQ and MSM-821 alloys.

Navy views beryllium with the same longing that other disciplines (such as aircraft, missiles, etc.) view it — completely captivated on the one hand by its strength-to-weight ratio and utterly chagrined on the other hand by its cost and fabrication problems. Nevertheless, it's in the running.

And all the while repeated efforts are being made to develop methods for mixing materials in a pressure-tight hull — joining titanium to steel, for example. Aluminum is still considered as a possible pressure hull material, but there appears to be a problems with respect to its fatigue life under many repeated deep depth pressure cyclings.

Low strength-to-weight ratio is the key. Thus, structural design as well as basic material strength is being researched (see article, p. 34 this issue). For example, music spring steel wire with a tensile strength of 600,000 psi is now commercially available; 700,000 psi wire is being produced in prototype quantities; and 1,000,000 psi wire is on the way. Question: How do you utilize this strength in the compressive mode? Work is underway on composite materials and structures, as well as hollow core structures.

In addition, serious consideration is being given to the use of fiberglass/plastic structures. Visualize, if you will, the extension of textile technology that would be required to fabricate a monofilament-wound glass reinforced plastic POLARIS submarine hull.

Plastic deformation characteristics of metals is yet another course of investigation. All current submarine hulls are designed to operate within the elastic deformation strength range — where the conventional hysteresis curve applies. But in most conventional structural materials there is quite a spread between minimum yield strength and ultimate tensile strength. What happens to a structure that is repeatedly stressed

beyond minimum yield strength? Is there a fatigue or work hardening problem in materials that are repeatedly cycled between the pressures of deep depth and sea level? These are just some of the structures and materials problems facing designers of deep-diving submarines.

Other answers — Supposing it turns out to be too difficult or simply too expensive to apply conventional techniques to the solution of these problems. What then? A first answer is to reduce the space and weight requirements of submarine-borne equipment. Transistorize all electronics equipment. Utilize airborne and missile-borne knowhow in the design of submarine subsystems such as generator sets, turbines, heat-exchangers, distillation sets, blowers, stoves, air purifiers, filters, etc. This will reduce the space required inside the pressure hull and therefore reduce the over-all weight.

Yet another approach getting considerable attention involves the mounting of much equipment now inside the pressure hull on the outside — under a fairing perhaps, but operating nevertheless at the ambient pressure, either oil or local seawater. First efforts in this direction are concerned with main propulsion power transmission. At deep depths sealing the main shaft against outside water pressure becomes an almost insurmountable problem. In addition the hydrostatic pressure on the end of the shaft (which, having to transmit on the order of 400,000 foot-pounds of torque, has an appreciable diameter) serves only to compound main thrust bearing problems.

One answer may be to eliminate the main shaft entirely, i.e., to mount an electric motor outboard of the pressure hull to drive the propeller after the fashion of a servo system. Towards this end, Navy has a continuing program for developing alternating electric current motors which will operate in seawater under pressure. Operating times running to hours have been achieved. Main problem remains, however, development of a proper potting compound which won't break down under high loads and thermal shock. Best results, so far, have been achieved with epoxies. This one is far from solved.

Shrinkage — But even supposing these problems are solved yet others remain. Not the least of these is shrinkage. Even with today's limited depth capabilities, submarines shrink in size (according, more or less, to a standard stress-strain curve) as they go down. Present shrinkage is well within the limits of construction tolerances. However, this isn't so when you're talking depths of 10,000 feet or more. Immediately problems arise with respect to piping, pressure ducts, mechanical linkages, etc. This will require a bit of "give" built in at no reduction in effectiveness. In a word, the submarine of the future will have to be capable of considerable "flex".

Vital Test Facility — Perhaps one of the most important contributions to the solution of these problems will be the Naval Engineering Experiment Station's deep submergence test facility for which NEES has requested funding. Consisting of 10 pressure chambers ranging in size up to 8 feet internal diameter by 20 feet long, these chambers will be capable of simulating the ocean environment to depths of 36,000 feet (15,000 psi), with full control over pressure, temperature, salinity. NEES has requested funding for this facility, but as yet has not received approval. Once completed, these facilities would be available to industry on a standard time lease basis.

To really get down there, below 20,000 feet, for example, is going to take even more doing. Not the least of the problems that will be encountered is the fact that at 20,000 feet the density of air equals that of the surrounding water and would be useless for blowing buoyancy tanks in the conventional manner. Thus, some other system will have to be devised — blowing the tanks first and then pumping down the pressure to reduce the air density, for example.

Underwater systems — sonar, weapons, countermeasures, etc. — that now perform in the oceans upper levels will be seriously handicapped or will fail to function at all great depths unless they are materially modified. The deep depths, in other words involve more than just going down. Practically every facet of submarine and submarine subsystems design will have to be reworked or even revolutionized. The same degree of challenge exists today in extending our underseas operational limits downward as existed in 1954-56 in our efforts to extend our operational realm beyond the earth's atmosphere. There are challenges of materials, structures, systems, new concepts, etc., in the ocean's depths which will push the state of the art just as severely, and in many camparable ways. It's going to be a tough technological market, but one that is financially rewarding.★

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See pp. 42-44 of January issue of UNDERWATER ENGINEERING for more information on Honeywell's underwater work.

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Circle Reply Card No. 20

Pulsed Ultraviolet Radiation For Submarine Detection?

By Andrew Madsen

Mr. Madsen, founder and Director of Research of AERO-DATA, holds a number of patents in the field of illumination including a basic patent in the airborne ultraviolet system. He was previously with Aircraft Engineering & Maintenance Co. as a consultant and prior to that was Director of Research with Sonic Power Co.

A NEW IDEA in the realm of submarine detection, which permits "visual observation" in the dark, is SEA-DATA, an airborne reconnaissance system employing pulse near-ultraviolet radiation. This unique and novel concept utilizes condenser-discharge flashtubes that emit large magnitude pulses of near-ultraviolet radiant energy to an appreciable area of the ocean's surface. Radiated in this manner, during conditions of darkness, the surface will exhibit coherent patterns of fluorescence and associated visual phenomena caused by various factors in the otherwise invisible wake evidence.

Application of this concept to ASW submarine detection would encompass an aircraft equipped with supplementary engine-driven generators (two units at 55 KVA) that supply current to the power supply which, in turn, charges banks of storage condensers (three banks at 32,000 watt-seconds each). The stored energy is discharged through the condenser-discharge flashtubes that are so arranged that a large amount of the radiant emission is in the near-ultraviolet spectrum. The energy is filtered so that the desired wavelengths are transmitted and the visible wave-lengths absorbed. A reflector, mounted in the aft section of the aircraft, beams the energy to the surface in a 60° beam pattern canted 10° forward of the nadir.

The three banks of condensers, through their associated flash tubes, are pulsed at 1500 milliseconds (ms), a dark period of 80 ms separates the individual pulses into groups of three. The distribution of the energy into three pulses allows visual perception of the desired phenomena by taking advantage of the persistence of retinal impression.

Observation of the radiated surface can then be made from a light amplifier video circuit. It is considered that this system will be capable of detecting the wake of a submarine operating at depths to 200 feet and at distances in excess of 5 nautical miles.

With these abilities the sweep rate would exceed 3,000 sq. nautical miles an hour with the speed of the search aircraft being 300 knots (sweep rate being calculated as equal to twice the effective lateral range of detection of the search aircraft equipment, multiplied by the speed of the aircraft). In operation, with the flight path being 2,000 feet over the surface, each pulse series will radiate approximately 4,000,000 sq ft (radiation beam pattern on the surface being, in area, approximately the square of the aircraft altitude). Between the groups of pulses (1500 ms.), during which time the condenser banks are being recharged, the aircraft will travel approximately 780 feet — the successive group of pulses will allow a greater than 50 per cent radiation overlap of the subject surface that received the prior group. The enormous energy possible with the condensed-discharge is due to the fact that they release accumulated electrical energy in less than 1 ms. giving each pulse an energy level of over 22 million watts.

Radiation

Calculations to determine the various characteristics of radiation, whether in the ultraviolet, visual or infrared are based upon three physical laws: **Stefan Boltzmann law** which gives the total radiation from an object; **Weins' displacement law** which gives the wave length for maximum radiation at any specified temperature; and **Planck's equation** which gives the radiation emitted by a Black body as a function of wave length.

Each of these laws makes use of the black body radiation, defined as the radiation emitted by an object which absorbs all incident radiation without reflection. Such radiation is greater in total energy than that emitted by any other type of material at the same temperature. Considerations for this proposed system have been made with the use of known spectral emission curves of standard Xenon flashtubes.

Transmission

The processes of transmission of any given form of energy through a medium are very similar. In each case a wave motion is set up in the medium and is propagated outward at a finite velocity in a desired direction. The transmitted power is distributed over a portion of the surface of a sphere, while the power-per-unit area gradually reduces inversely as to the square of the distance. In addition, power losses which occur in the medium rise exponentially as the distance increases. According to some recent work performed, haze interference phenomena does not, in practice, conform to Rayleigh's law. Specifically, Rayleigh's law states that the scattering of radiant energy caused by atmospheric haze is inversely proportional to the fourth power of the wave length, consequently there would be a great reduction in contrast between an object and its background. The recent work in this area (Wright Field) indicates that the presence of impurities in the atmosphere on which moisture particles can condense, creates haze conditions for which Rayleigh's law is inapplicable, thereby lending encouragement to this ASW concept.

Luminosity

When a beam of radiant energy is incident on matter (solid, liquid or gaseous), it is divided in three ways. It can be absorbed (which constitutes its being converted to another form of energy) scattered (reflected in other directions), or transmitted (continued in the same direction). Visual light luminosity or fluorescense, occurs as a function of the absorption of the ultraviolet radiation. In addition to the readily apparent fluorescent charter of the hydrocarbon particles left in the wake of a submarine, such factors as the thermal anomolies caused by the passage of a submarine will cause a differential in the absorption characteristics and give information through the addition of luminosity

or attenuation of luminosity in what might be termed the ever present, when radiated as suggested, background fluorescence of the surface of the ocean.

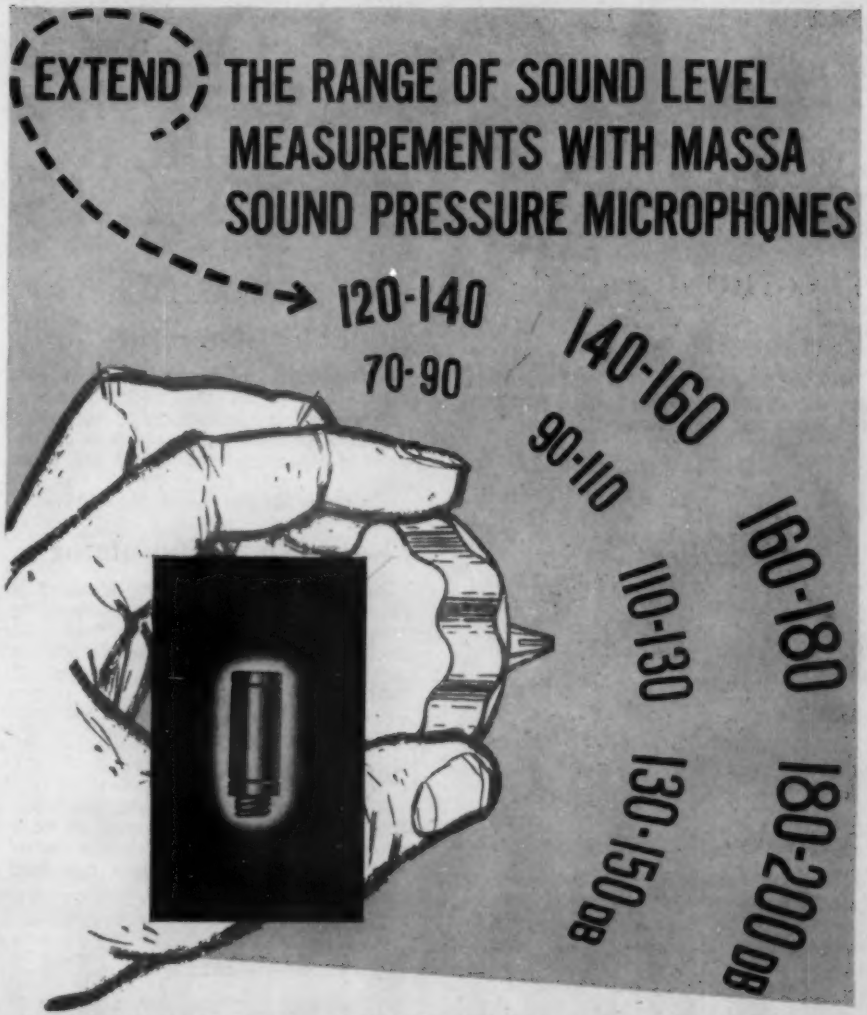
Stokes law, stating that the radiation emitted by a fluorescent body must be of longer wave length than absorbed, is based on two facts: (1) Relatively large quanta are required to raise electrons to the high excitation energy levels from which flurescent or phosphorescent processes may begin, and (2) transition of excited electrons to the stable level usually occurs in short steps giving rise to small quanta and associated longer wave lengths.

Effective Intensity and Flicker Phenomena

It is recognized that when a light signal consists of separate flashes, the instantaneous intensity during the flashes must be greater than the intensity of a steady light in order to obtain threshold visibility. Blondel and Rey found that the threshold illuminance for an abrupt flash is $E = E_o\ (a + t)/t$, where E_o is the threshold illuminance for a steady light, t is the flash duration, and a is a constant. They found that a was equal to 0.21 when t is in seconds. Application of this relationship to target sightings to groups of short period illumination in rapid succession so that this group is seen as a single event, is an area in which no published data is available; but it is known, that when the dark period is between 0.01 and 0.1 seconds, the effective intensity will lie between that of a single event and that of the group.

Intermittent stimulation by light is a phenomena associated with flicker. A fundamental characteristic of flicker phenomena is expressed by the Talbot-Plateau law. This states that intermittent light stimuli of any sort, when presented at a frequency sufficiently high to eliminate flicker, has an effect on the eye indistinguishable from that due to the same total light flux continuously and uniformly applied.

From the standpoint of physics, the only difference between radio waves, visible light, and ultraviolet rays lie in their wave length. Out of this vast range of electromagnetic radiation the human eye selects only the permitted narrow band. Man's perception is thus restricted by the limitations of his visual sense. The conversion of absorbed near-ultraviolet radiation to visible light, within the purpose and means of this concept, will expand man's ability to see situations and events that are not presently possible.★



AVAILABLE IN FREQUENCIES FROM 20 CPS to 90 KC

Massa Sound Pressure Microphones employ ADP (Ammonium DiHydrogen Phosphate) crystals as the active elements for the best combinations of *reliability, stability,* and *accuracy.* These proven microphones are in widespread daily use in highly critical fundamental acoustic measurements over both the audible and ultrasonic ranges.

For example, in the study of scaled-down test jet and rocket engines, the resonant frequencies reach well into the ultrasonic frequency range. Without adequate microphones subtle sonic waveforms, indicative of expected full scale sounds, will be missed.

Massa Sound Pressure Microphones Provide:

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- **Omni-Directional Pattern:** For sure pickup of sound in difficult areas.
- **Small Size:** Diameters from 5/16 inch to less than ¼ inch . . . for easy probing of small cavities.

*above 0.0002 microbars.

There is a complete line of Massa Sound Pressure Microphones from which you may select the unit best suited to your application.

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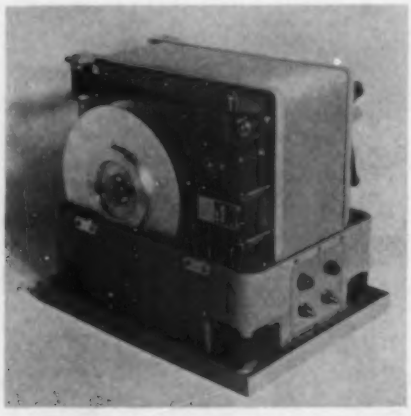
Circle Reply Card No. 21

new u s t products

ELECTRONICS

Portable Recorder

Minneapolis-Honeywell has introduced a portable digital recording system designed for unattended data acquisition over long



periods. Thirty-eight hours of continuous recording can be handled with one reel of tape for such applications as seismology, underwater level surveys, oceanography, and many others.

Circle Reply Card No. 101

Pulse Generator

General Applied Science Labs has announced a new pulse generator, the Model PG-10, for use where high repetition rates and narrow pulses are required. Frequency range is 1 to 20 mcps in three overlapping ranges with an accuracy of 3 per cent of the dial setting. Some of its many uses are for timing or switching circuits, delay lines or wide band amplifiers.

Circle Reply Card No. 102

Voltage Monitor

A new instrument, designed to protect costly equipment, has been introduced by Electronic Measurements Co. The unit continuously monitors dc power supply output in the range from 0 to 100 volts.

Circle Reply Card No. 103

Digital Recorder

Navigation Computer Corp. announces the Model 1150R Digital Recording System, for converting analog voltages, in the range of 0 to +9.9 volts, to a 2-digit binary decimal code. Maximum conversion time is 200 microseconds, yielding a minimum parallel conversion rate of 5 KC.

Circle Reply Card No. 104

Feed-Thru Capacitor

Effective by-passing of r-f interference on low-voltage d-c power circuits can now be achieved with a new feed-thru capacitor from Sprague. The case acts as the ground while line current passes directly through the tantalum pellet from terminal to terminal.

Circle Reply Card No. 105

Modular Generator

A transistorized pulse and time relay generator, designed on the modular building block concept, is manufactured by Rutherford Electronics Co. Units are available in a wide range of repetition rates, delays and pulse widths.

Circle Reply Card No. 106

Electronic Commutator

United Electro-Dynamics has developed a low-level electronic commutator incorporating mechanical commutator features and high speed capabilities attainable with electronic switching. Contact resistance averages 12 ohms.

Circle Reply Card No. 107

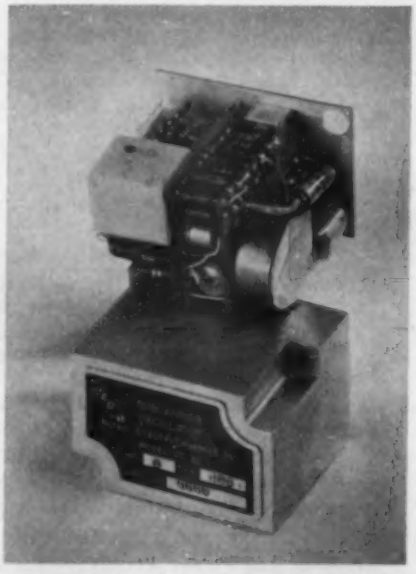
Servo Analyzer

An all electronic servo analyzer which provides direct reading phase and amplitude measurements vs. frequency for electronic, electromechanical or mechanical servo has been announced by Remanco, Inc.

Circle Reply Card No. 108

Tiny Oscillator

A subcarrier oscillator with a volume of only 2 cubic in. that will operate from signal sources as low as ±10 mv is being marketed



by United ElectroDynamics, Inc. The high output (4.1 volts rms into 2000 ohms) eliminates the need for multiplexer amplifiers.

Circle Reply Card No. 109

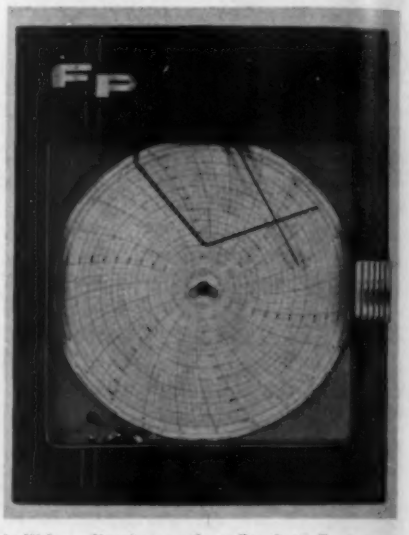
In-Circuit Tester

A unit, the ICT-100, capable of testing transistors, diodes, or rectifiers (germanium or silicon) while they are in or out of circuit, has been introduced by Molecular Electronics, Inc. The item will perform a variety of tests including measuring salient characteristics and detecting shorted, open or leaky semi-conductors.

Circle Reply Card No. 110

Solid-State Recorder

A rugged and compact recorder having fully transistorized circuitry, positive drive action, a



built-in voltmeter, and a direct-reading range dial has been introduced by Fischer and Porter Co. Automatic quadrature rejection is provided.

Circle Reply Card No. 111

Solid State Switch

Alpha-Tronics Corp. has announced a solid state low level switch designed to switch input signals within a range of 0 to ±1 volt and with a resolution of 5 microvolts. Switching transient is less than 4 millivolts.

Circle Reply Card No. 112

Translator

A new miniature DC-in DC-out translator is being produced by Physical Sciences Corp. as instrumentation used in the measurement of displacement, pressure or acceleration in telemetry systems. Accepts input voltage of between 6 and 12 volts.

Circle Reply Card No. 113

MISCELLANEOUS

Discriminator Cavity

A dual-mode transmission-type discriminator cavity designed to operate at 35 kmc has been developed by Westinghouse. The frequency stabilizing device can be used for such applications as parametric amplifier pumps, navigation systems, and beacon radars.

Circle Reply Card No. 114

Detector Tube

A new line of Geiger-Mueller tubes is announced by the Victoreen Instrument Co. Some of the tubes are halogen-filled for high level gamma detection, some have mica windows permitting beta detection, while others are a combination of both.

Circle Reply Card No. 115

SOFAR Bomb

A new SOFAR (sound fixing and ranging) sound generator for underwater detonation has been designed and perfected by the MIMX

Corp. The unit, lightweight and compact in size, is used to fix the reentry locations of missiles and orbital test vehicles or bodies in order to expedite their recovery from the water.

Circle Reply Card No. 116

Flaw Detector

The Metalloradar, a unique ultrasonic flaw detector which operates without coupling has been introduced by Circo Corp. Capable of flaw

detection from irregular surfaces, the unit employs an ultrasonically-vibrating crystal which is intimately coupled to the object being tested.

Circle Reply Card No. 117

Power Unit

Peschel Electronics, Inc. has designed and built a 15,000 volt DC power unit composed of a high voltage section and a small remote control box. The unit is used in process work for electrostatic charging, particle separation, capacitor charging and similar applications.

Circle Reply Card No. 118

Crystal Filters

Collins Radio Co. announced a new line of crystal filters for telemetering, missile guidance, radar and navigation equipment and other electronic uses, covering the 10kc to 30 mc frequency range.

Circle Reply Card No. 119

Air Conditioner

A compact air conditioning unit has been designed by Budd Electronics, specifically for mounting in electronic racks. Temperature is controlled automatically by an adjustable hot gas by-pass regulating valve.

Circle Reply Card No. 120

Temp Controller

A digital, set-point, on-off temperature controller, combining the high stability of a platinum resistance temperature transducer with the simplicity of digital type setting and display is now being offered by Winsco Instruments & Controls Co. Completely transistorized, it covers the range from 0° to 2000° F.

Circle Reply Card No. 121

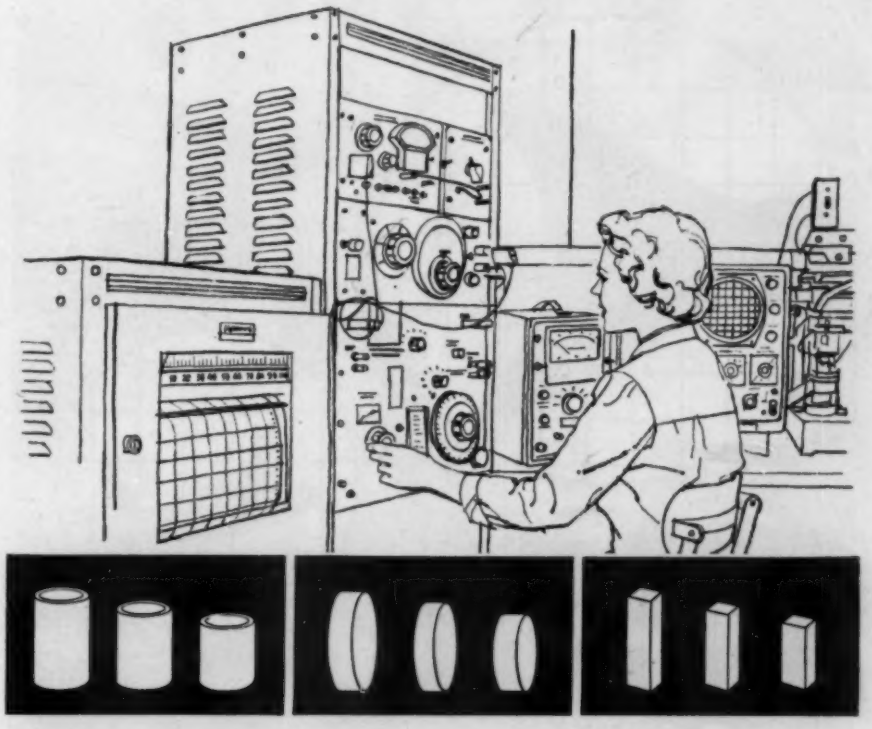
All-Angle Blower

All-angle panel-mounted blowers developed by Western Devices, have twin scrolls that can be rotated and set to any angle of choice through 230°. Diverse air flow patterns can be created by reversing the motor-rotor assembly.

Circle Reply Card No. 122

FROM HONEYWELL . . .

Built-in reliability and uniformity for ceramic transducers



Specialized production techniques at Honeywell have resulted in lead zirconate/titanate and barium titanate ceramic transducers with greater reliability and uniformity.

Honeywell's skill in custom-building piezoelectric ceramic elements from lead zirconate/titanates and barium titanates of varied piezoelectric properties lets you select units keyed to your exact needs. This selectivity can provide for greater range in sonar systems, improved operating efficiencies, lower dielectric losses at high AC driving voltages, high electro-mechanical coupling and excellent aging characteristics.

To meet the demands of modern underwater scanning systems, Honeywell established a ceramics facility devoted to building lead zirconate/titanate and barium titanate transducers. Ceramic parts for transducers can be produced to dimensional and electrical tolerances to meet your requirements.

Honeywell transducers are built in a wide variety of shapes and forms, and are available in quantity and economy consistent with long experience in quality units.

Honeywell's ceramic skills are backed by 76 years of corporate leadership in the field of control concepts and the design of systems, instruments and computers for a multitude of commercial, industrial and military applications. For further information regarding Honeywell piezoelectric ceramic transducers, write Honeywell, Dept. UW-5-129, Minneapolis 8, Minnesota. *Sales and Service offices in all principal cities of the world.*

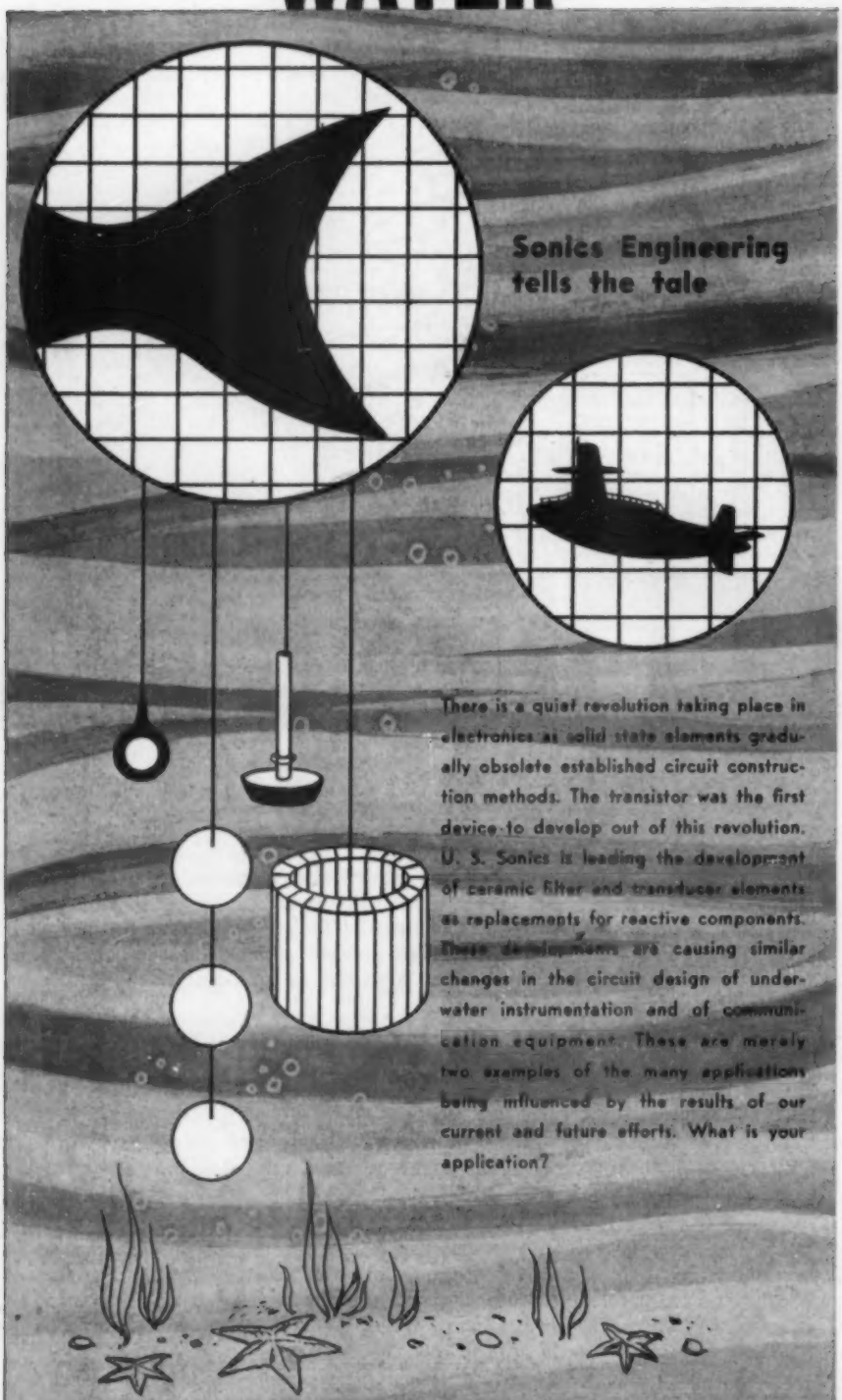
Honeywell

First in Control

SINCE 1885

Circle Reply Card No. 22

A-FISH-END UNDER WATER


Sonics Engineering tells the tale
There is a quiet revolution taking place in electronics as solid state elements gradually obsolete established circuit construction methods. The transistor was the first device to develop out of this revolution. U. S. Sonics is leading the development of ceramic filter and transducer elements as replacements for reactive components. These developments are causing similar changes in the circuit design of underwater instrumentation and of communication equipment. These are merely two examples of the many applications being influenced by the results of our current and future efforts. What is your application?
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Circle Reply Card No. 23

new ust

Tube Application

A new booklet, "Electron Tube Application Notes", has been announced by Sylvania Products Inc. The 58-page illustrated brochure reviews many of the do's and the don't's of tube applications.

Circle Reply Card No. 123

Amprobe Cable Tracer

Details of a new instrument designed to speed the tracing of electrical conductors are available from a new catalog sheet offered by the Pyramid Instrument Corp. The catalog also lists specifications, features and applications.

Circle Reply Card No. 124

Subminiature Tubes

Three 12-page handbooks describing cathode subminiature, filamentary subminiature, and gas and vapor electron tubes have been published by Raytheon for equipment design engineers.

Circle Reply Card No. 125

Tube Characteristics

A 32-page booklet describing industrial electron tube applications and characteristics is being offered by The Machlett Labs. Each of the 6 divisions is prefaced by a discussion of the mechanical and design criteria for each major tube type.

Circle Reply Card No. 126

"The Zener Diode"

CBS has announced their latest 4-page bulletin in the TECH TIP series on the "Zener Diode", covering theory, and offering typical circuits for the diode usage.

Circle Reply Card No. 127

Control and Line Valves

Ledeen, Inc. has released a bulletin covering their line of "Spanseal" control and line valves designed for pneumatic and hydraulic service.

Circle Reply Card No. 128

Water Separators

The Bendix Corp., in a 6-page technical bulletin, discusses operating principles as well as dimensional flow specifications of filter-water separators and conversion kits. A list of refueler trailers and filter units that can be converted is also included.

Circle Reply Card No. 129

New Facilities

A new facilities brochure outlining capabilities for defense electronics has been published by Loral Electronics Corp. The brochure gives a profile of the company's activities which include ASW systems, countermeasure applications, navigational computer studies, etc.

Circle Reply Card No. 130

literature

Soldering Irons

A four-color catalog introducing the new Imperial iron has been released by Ungar Electric Tools. Complete with photos, the catalog covers interchangeable handles, cords, tips, cartridges and accessories.
Circle Reply Card No. 131

Slide Rule & Wall Chart

A specially-designed slide rule and a wall chart, both featuring selection of more than 345 styles of control knobs, are offered from Raytheon for design engineers use.
Circle Reply Card No. 132

Selective Plating

Selectrons, Ltd., announces a booklet listing varied industrial and marine uses of a new, high-speed selective plating process. The booklet contains a chart indicating deposition rates, metal concentrations and recommended current densities.
Circle Reply Card No. 133

Back-Up Rings

A new booklet of design, dimensions, characteristics and other data on back-up rings is now available from the Parker Seal Co. The book discusses advantages of contoured and continuous rings.
Circle Reply Card No. 134

Electronic Products

Radio Parts Co. has recently issued a 224-page catalog listing the latest industrial electronic products with specifications and prices. A total of 115 manufacturers are included in this comprehensive representation.
Circle Reply Card No. 135

Turbine Flowmeters

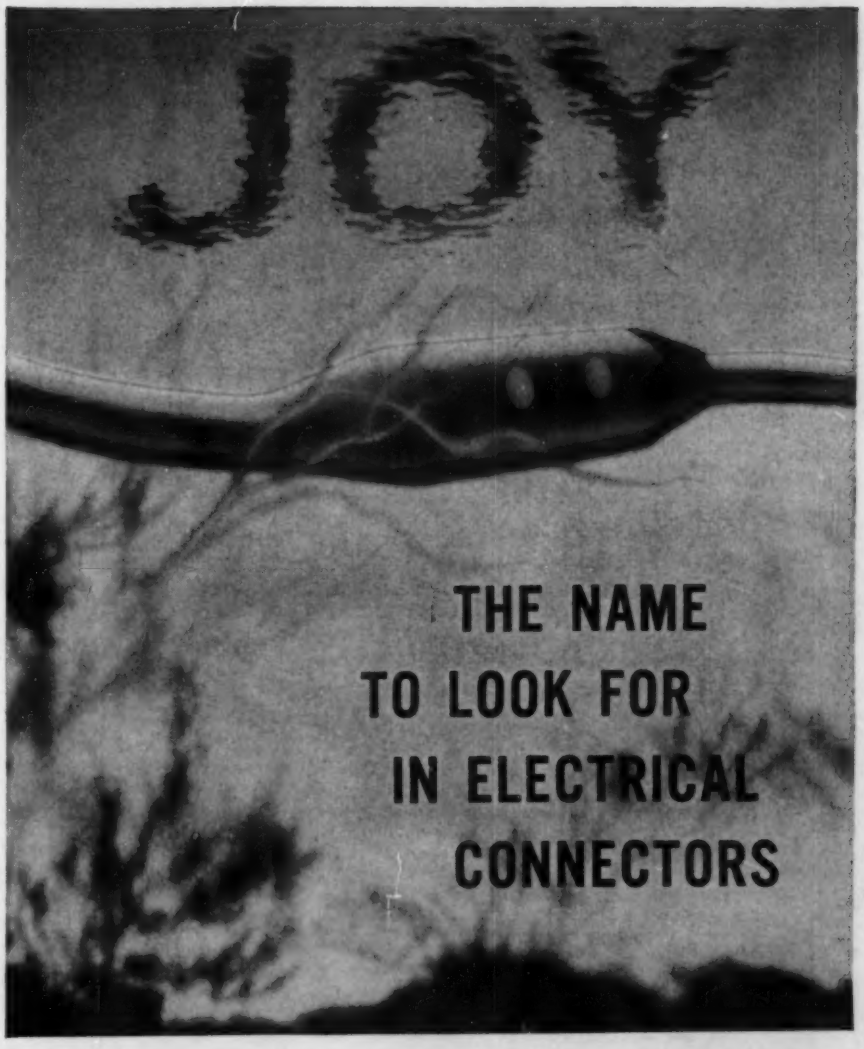
Two new models of a turbine flowmeter are described in a specification bulletin released by Fischer & Porter Co. Six new transistorized totalizers and batch controllers designed for use with the meters are covered.
Circle Reply Card No. 136

Pocket Dynamometer

Literature on a new pocket dynamometer for measuring torque and power loading of small electric motors is available from Micropump Corp. The direct reading instrument weighs only 2¼ pounds.
Circle Reply Card No. 137

Coaxial Cable

A 40-page, fully illustrated catalog, from Prodelin, Inc., describes reactance-compensated rigid '800' aluminum and copper transmission lines. Also included is data on connectors, flanges, supporting hardware and dehydration accessories.
Circle Reply Card No. 138



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Material: resilient, durable, highly resistant to shock, vibration and other severe treatment.

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TRANSDUCER DESIGN:
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10400 Aviation Blvd., Los Angeles 45

Circle Reply Card No. 25

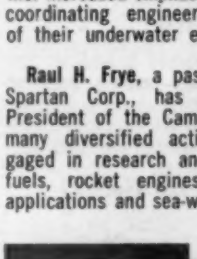
u s t

people and

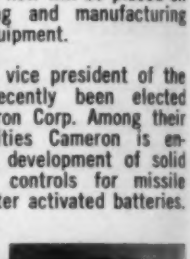
The appointment of **Dr. Cameron Knox** to the newly created position of corporate director of research has been announced by Acoustica Associates, Inc. A specialist in oceanography, Dr. Knox will direct a group of prominent scientists in long range studies in oceanography and underwater acoustics. Most recently, he retired from the Army after serving as colonel with the Joint Chiefs of Staff.

A. C. DeNapoli, former chief electromechanical engineer for Motorola, has been appointed Vice President Engineering and Manufacturing for Massa Div., of Cohu Electronics, Inc. Increased emphasis now will be placed on coordinating engineering and manufacturing of their underwater equipment.

Raul H. Frye, a past vice president of the Spartan Corp., has recently been elected President of the Cameron Corp. Among their many diversified activities Cameron is engaged in research and development of solid fuels, rocket engines, controls for missile applications and sea-water activated batteries.



Knox



Freseman

Radio Engineering Laboratories, Inc. has announced the appointment of **Rear Admiral William L. Freseman,** USN (Ret.) to a new post of assistant to the president. An authority in the fields of communications and radar, Mr. Freseman previously was Vice President of International Standard Engineering, Inc., a subsidiary of IT&T.

Tenney Engineering, Inc. has organized independent divisions for its aerospace and environmental equipment, with **Frank H. Gardner** and **Martin Schletter** as managers of the respective operations. Both are veteran development engineers at Tenney.

James B. Meagher has been appointed Marketing Manager of Marine Equipment Dept., Nortronics Div., Northrop Corp. Mr. Meagher will be responsible for marketing and contract management in the area of advanced inertial navigation systems.

Isidor B. Seidler, president of Flomenhaft, Seidler & Co., Inc., Wall Street securities firm, has been elected chairman of the Board of Directors of Electromagnetic Industries, Inc., manufacturer of transformers, magnetic components and electronic instrumentation.

William H. Moore, long-time Department of Defense official, has joined the Electronic Industries Assoc. staff as Vice President of the Military Products Division. He will direct all staff activities in this division and will also be in charge of EIA's industry liaison with the DOD and the military services.

employment

Defense Information, Inc. has appointed **John E. (Ned) Mulroy** vice president and Executive Director. Mr. Mulroy will head up the company's Anti-Submarine Warfare service, and its Defense-Industry consulting and patent services.

Dr. J. Richard Hechtel has joined the staff of the Research Laboratory of Litton Industries' Electron Tube Division as a senior scientist. For the past three years Dr. Hechtel has been head of the microwave tube branch, Naval Ordnance Test Station, China Lake, Calif.

Radiation Inc. has named **John T. Hartley** Vice President, Corporate Marketing. Mr. Hartley, with the company since 1956, will be responsible for an integrated corporate sales effort for all divisions and subsidiaries.

Appointment of **J. M. Gardiner**, as assistant to the President was announced by the Thiokol Chemical Corp. Mr. Gardiner will represent Thiokol's over-all operations, including specialties and chemical operations in the Washington, D.C. area.

Mulroy

Niles

PRD Electronics, Inc., manufacturer of electronic instrumentation, has appointed **Morris M. Kemple** as project manager. He will be responsible for Fighter Systems studies on PRD's project "NAVSEA". **Edward Webster** was also named as military projects manager.

Dual appointments of **Walter H. Niles** to president and **Joseph Brewster** to executive vice president have been announced by Guidance Controls Corp. Both were promoted from prior positions within the company.

J. Nelson Lord, Jr. has joined the Washington, D.C. staff of General Dynamics/Electronics. Mr. Lord comes to General Dynamics from the Allen B. DuMont Labs. where he was assistant to the Vice President.

F. W. Witzke has been appointed vice president and chief administrative officer of the Cleveland Instrument Company, a subsidiary of the Bendix Corp. Mr. Witzke has been active in the design and marketing of new gage designs and has several patents pending in this field.

Appointments of **Ervin J. Osterhus** as executive vice president and **Walter J. Hood** as vice president Engineering were announced by Designers for Industry, Inc. Both promotions were made from within the organization.

Victor Wire and Cable Corp., fabricator of specialty wire and cable for electronics, missiles and aircraft, is now being headed by a new president, **Leon Feldman.**

capital report ★★★★★★

By E. E. Halmos

Undeterred by the recent collapse of a "Texas Tower" radar platform off the New Jersey coast, the Coast Guard is going ahead with its plans to replace two of its 22 lightships with similar structures. Bids were opened at Boston in mid-April for construction of two four-legged platforms that will replace the Buzzards Bay and Brenton Reef lightships.

Buzzards Bay will be a real engineering challenge: The water is a little more than 60 ft deep, but preliminary borings indicate that the legs will have to be sunk about 210 feet through bottom sand to reach a firm footing on rock; and rough water is the rule, rather than the exception, at the location. (The tower will stand about 70 ft above water, so its concrete-will be 70 x 70 ft, with an upper and lower deck, providing accommodations filled pipe legs will be more than 338 ft long). The tower platform itself for a 5-man crew, plus the light, foghorn and necessary equipment.

Brenton Reef (off Narragansett Bay) will be smaller and much cheaper. It will have no permanent crew, and the real difference lies in the fact that there's good rock within about 14 ft of the sand bottom, and that power can be supplied by submarine cable from the shore.

Bidding on the two towers provided some interesting sidelights. Coast Guard has appropriations of about $1.7 million to cover both. Low bid on both was $1.4 million, second-low bid $1.7 million. Just before bids were opened, CG's construction officer at Boston said he thought the cost for both would be about $1 million — and obviously incurred the displeasure of Washington headquarters which didn't think any estimate should be released in the first place, and obviously didn't believe the $1 million figure possible, considering the construction difficulties involved.

A somewhat piecemeal — but immediate — attack on the vast problems of Oceanography is the indication contained in President Kennedy's request for an added $23.5 million for 1962 spending on research and other activities. The money would be added to the roughly $72 million for this purpose sought in the final Eisenhower budget. Money is to be spent by such diverse agencies as the Department of Defense, Commerce, Interior, Treasury, Health, Education & Welfare, National Science Foundation and Atomic Energy Commission.

What's interesting in Kennedy's approach is that he apparently isn't willing to wait for Congress' slow and careful approach to the problem of finding out what's in and under the seas through carefully drawn legislation (as you may know, there are several bills to set up a 10-year Oceanographic program in the Congressional hoppers now). He wants faster action—because of the overriding needs of defense.

U/E's readers will be interested in the details of what the Kennedy proposal is to provide: $37 million for construction of ships — a total of 10 new or converted oceanographic vessels; $10 million for shoreside research facilities; $41 million for basic and applied research. Other funds will go toward training of oceanographers and specialists of all kinds; to finance world-wide surveys of the oceans; and to provide for cooperative efforts with other nations.

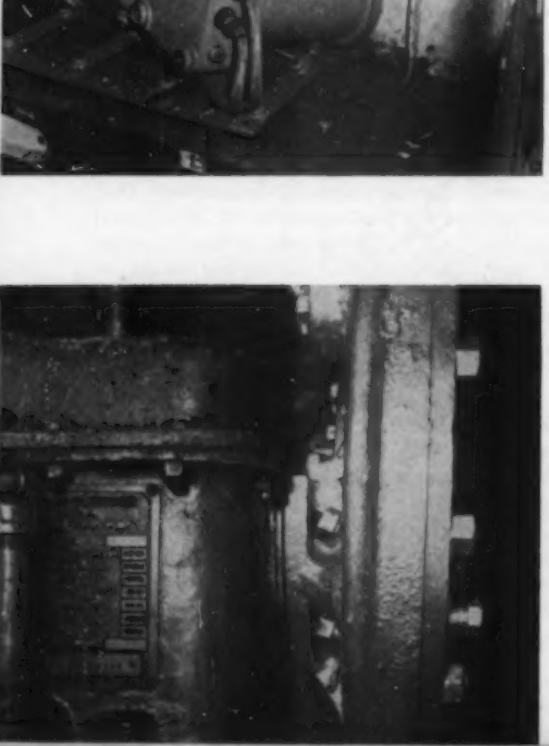
The President's request for added Oceanography funds was followed very closely by three significant developments: Introduction of legislation that would remove statutory limitations restricting participation of the Coast Guard in such research; the announcement that the Maritime Administration has asked bids on construction of two hydrographic surveying ships — with an option for construction of a third; and a further lengthy discussion of Soviet activities in using its big fishing fleet for oceanographic (and other) purposes. Bothering Washington's Senator Warren Magnuson was continuing evidence that Soviet "fishermen" are getting into every open body of water in the world (and some that aren't open) and seem to be spending more time in making maps and soundings than in catching fish.

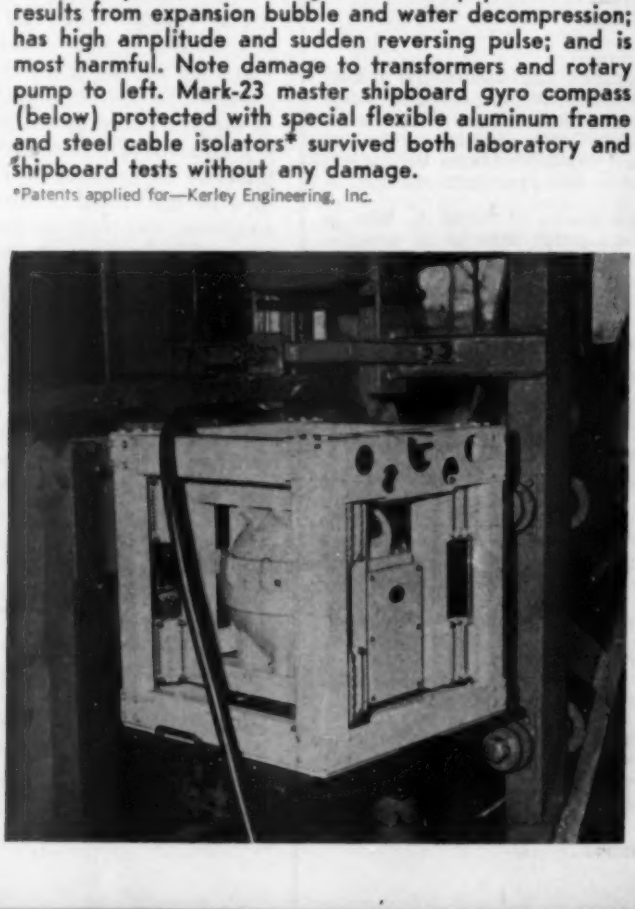
On oceanography, by the way, you should take note of the voyage of the Coast and Geodetic Survey ship *Pioneer* which started in April and is to cover 3 million square miles of ocean between the Hawaiian and Aleutian Islands. It'll be the U.S. government's first serious attempt to study wide ocean areas with systematic, closely-spaced observations. The *Pioneer* will navigate along a series of north-south lines spaced 10 miles apart across an area about 300 miles wide and 2,000 miles long.

scanning undersea technology

Here, ust shows Navy's USS Fullam undergoing one of a series of eight simulated underwater nuclear blasts. BuShips' and Defense Atomic Support Agency's program tests survivability of critical shipboard equipment. Blast creates two shocks: One, at detonation is sharp; moves at sonic speed; and damages brittle equipment. Other results from expansion bubble and water decompression; has high amplitude and sudden reversing pulse; and is most harmful. Note damage to transformers and rotary pump to left. Mark-23 master shipboard gyro compass (below) protected with special flexible aluminum frame and steel cable isolators* survived both laboratory and shipboard tests without any damage.

*Patents applied for—Kerley Engineering, Inc.





Heel and Toe Watch

Back to the old guessing game again: Latest ratings on the Navy's CNO tote board give Russell best odds to take over from Burke, with Hayward and Anderson bringing up show and place spots respectively.

Rumors that POLARIS A-2 missile will be by-passed are without foundation. The 1,500-mile A-2 is coming along too well (8-out-of-10 firings completely successful) to be dropped, and besides "We need the additional sea room as soon as we can get it."

Strike reports that SUBROC will become operational during this calendar year. Bird's coming along well, but not that well. Facts are: SUBROC is now undergoing live underwater firing tests at both China Lake and San Clemente Island, and is scheduled to be fired from THRESHER late in the year. It will be operational in 1963, and at that time POLARIS submarines have first priority.

Navy's RUM (Remote Underwater Manipulator) vehicle has hit a snag—it can't see well enough at depths where no light penetrates from above. Problem is that TV cameras are blinded by diffusion of RUM's headlight system. One solution may be to pulse both the light and the TV cameras in such a way that image orthicon tube is off while lights are transmitting pulse and on only at the instant that the reflected image returns (at which time lights are off). Since pulse frequency would have to vary with range, this would take some pretty clever (and expensive) circuitry. Another possibility is to "look" with something besides light.

RUM is quite important since Navy plans it as a remote controlled underwater constructor in some of its more sophisticated underwater defense systems.

We get reports that there are plans afoot to plant nuclear powered sound sources about the ocean floor. Now, how would we like if the fish came up here and planted a siren in the middle of our home town that we couldn't turn off?

Look for two new underwater navigation aids to be perfected: One measuring magnetic field strengths and angles (for which precise magnetic mapping of the earth has been under way for some time now); and another plotting the course by following contours of the ocean floor. Both will require instrumentation far more sensitive than is available now.

Submarines with jackets may not be far away. Considerable work has been done and remains to be done, but Navy's hoping to develop a special coating for submarines which will (a) dampen sound generated within the submarine and (b) permit boundry-layer control to reduce parsite drag and prevent cavitation.

What about high-speed interceptor submarines launched from a mother submarine for ASW? These craft could be powered by hydrogen peroxide or fuel cell systems; be capable of high speed and maneuverability for relatively short periods of time. Might be one answer to the dollar problem in ASW.

Captain Nemo

Merrill-Stevens

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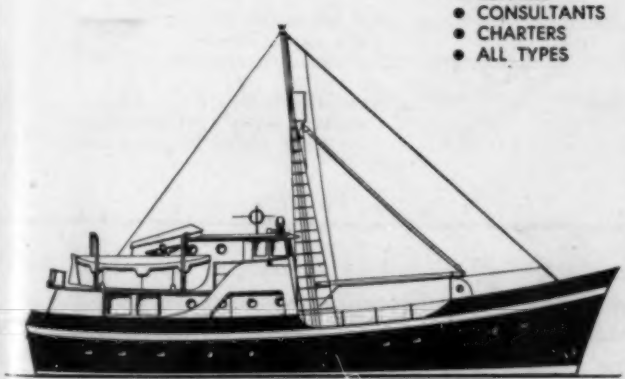

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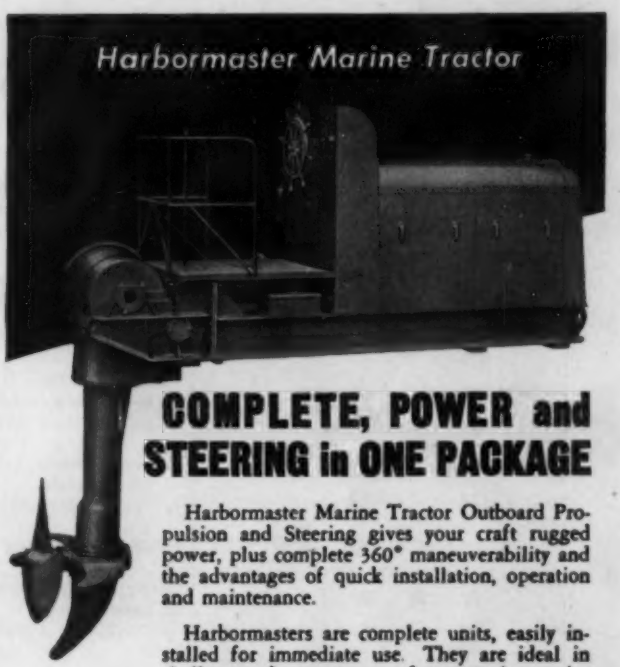

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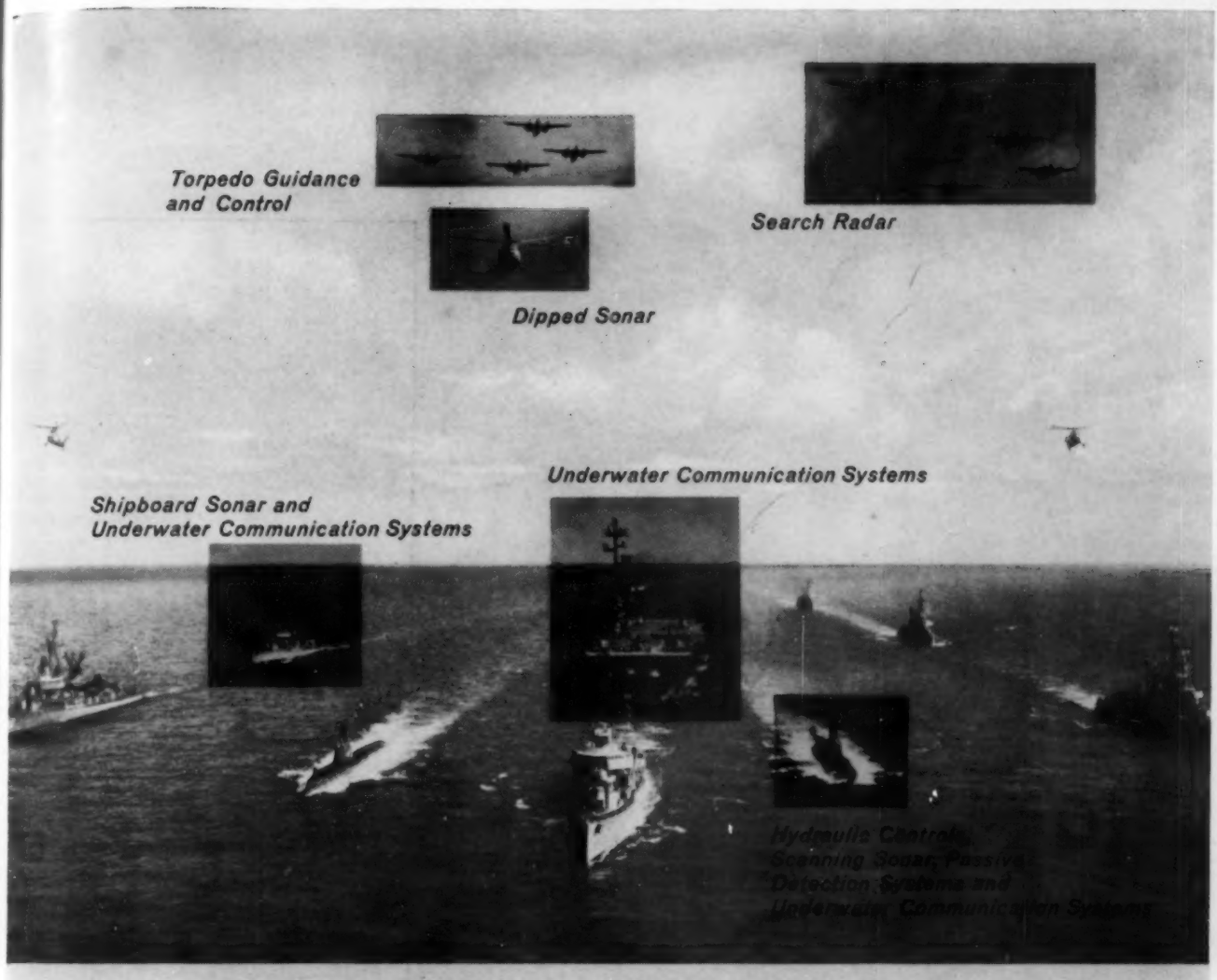
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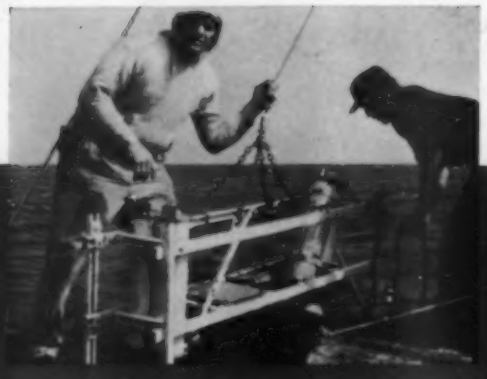

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▼ **Automatic Underwater Photography Systems.** This automatic oceanographic photography system has been used at depths to 27,000 ft. and is test-proven for use at the ultimate ocean depths.

Powered by self-contained batteries, the unit needs no electrical cables to the surface.

A camera-mounted sonar pinger is used to position the camera at the proper distance above the ocean floor. Once the camera unit has been positioned, photography is automatic and two cameras make stereo pairs of photographs on 35 mm. film every 12 seconds for 100 minutes using an integrated electronic flash for illumination. Depth, pressure, time, location, date and ship identification data are automatically logged with each exposure. Two models are available: CA-9 for use in depths to 37,500 ft. and CA-8 for depths to 6,500 ft. For complete specifications, write for Data Sheet #2000

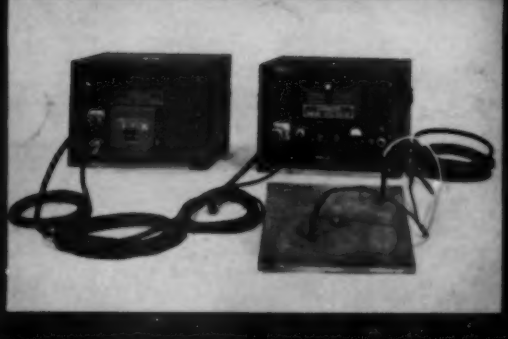
▼ **Sonar Pinger.** This battery-powered device is finding ever increasing applications in oceanography.

The unit will run for over 16 hours on one charge giving out one 12 kc ping per second at an accurately timed rate. This precise timing allows a recorder on the ship above to be synchronized to the pings. By comparing the time of arrival of the direct pings with that of the bottom reflected pings the distance from the pinger to the ocean bottom is shown.

Sonar Pingers are used in positioning oceanographic instruments such as underwater cameras, coring tools, water sampling bottles, etc. . . . and in making detailed bathymetric surveys of the ocean floor. Write for Data Sheet #3000.

▼ **Sonar Thumper — A new, high intensity underwater sound source.** This electronic device was developed primarily for making marine seismic surveys. It emits a high intensity "thump" underwater at a rate of up to 2 per second. The echoes of the "thump" show not only the water depth, but the geological structure of the bottom. This information is invaluable to those making underwater constructions, such as missile launching platforms, transducer arrays, breakwaters, tunnels and bridges. The unit delivers a clean, highly consistent pressure waveform.

Additional applications include underwater sound transmission studies, missile impact simulation and navigational applications. Complete specifications on request.



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